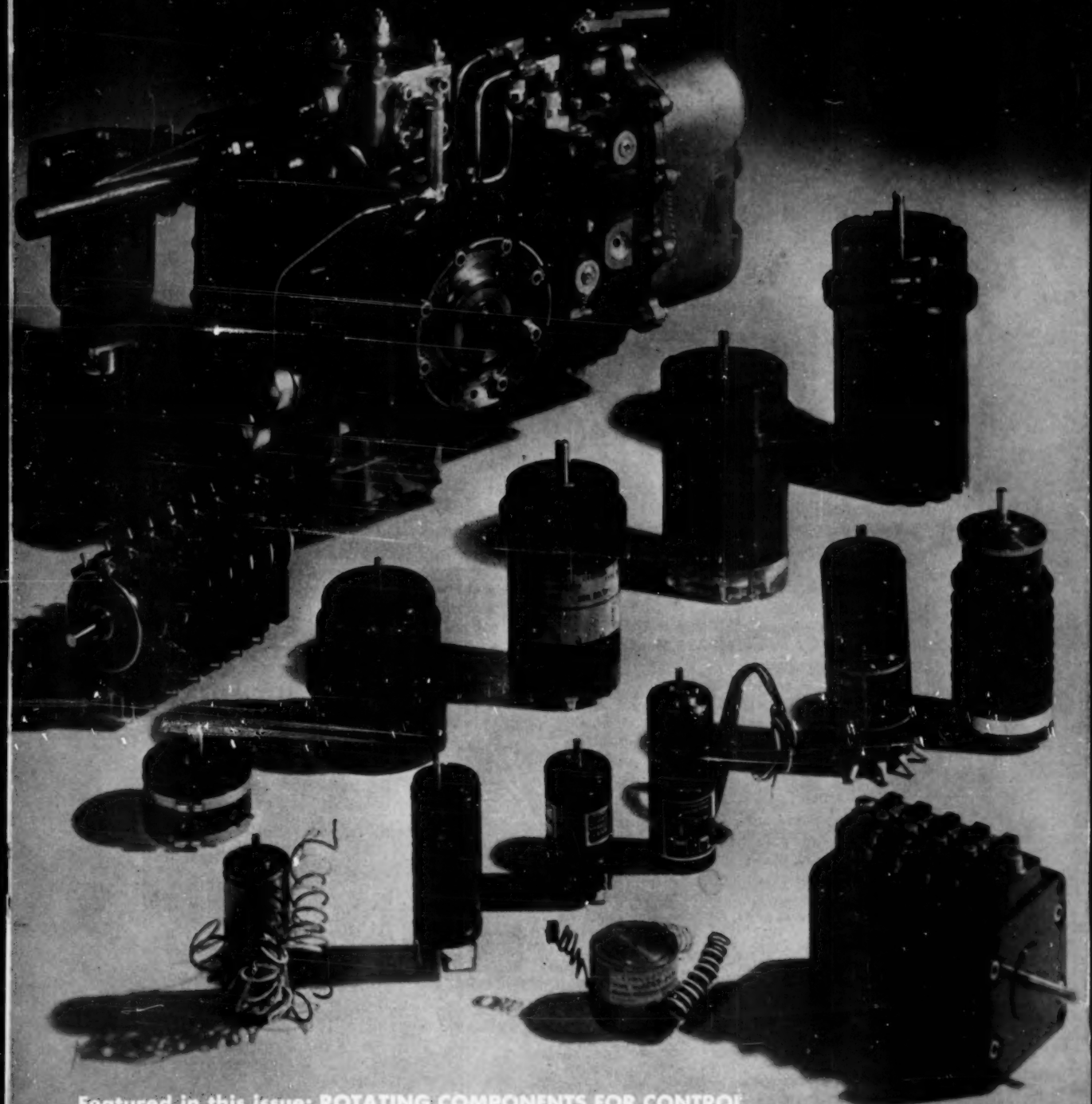
Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING • FIVE DOLLARS A YEAR

NOVEMBER 1953



Featured in this issue: ROTATING COMPONENTS FOR CONTROL

TOUGH PROBLEMS AND THEIR GREAT SOLUTIONS

The Alchemy of Light

Far surpassing in importance the transmutation of metals, for which the ancient alchemists strove, is the modern transformation of light to a useful force.

Television, like so many other great advances, rests on the utilization of a basic natural law: in this case that the element selenium, when exposed to light, generates an electric current.

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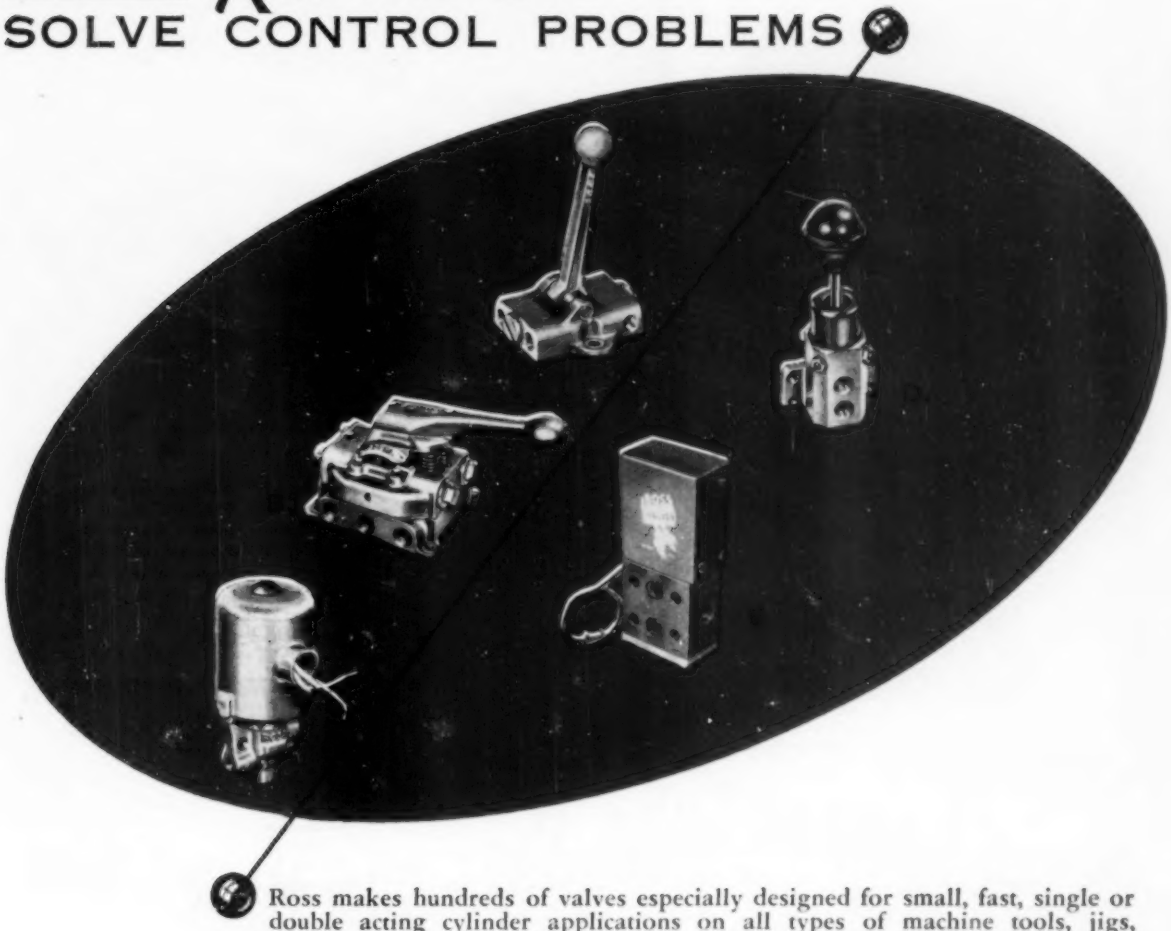

Ross makes hundreds of valves especially designed for small, fast, single or double acting cylinder applications on all types of machine tools, jigs, fixtures, small punch presses and for remote pilot operation of large valves.

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How it is possible to make such tight turns is Rome-Turney's secret. Revere does not share in it, nor does Revere want to reveal a secret of its own, which is how we turn out copper tube in a special bending temper for an application such as this. All we can say is that the two methods dovetail very nicely. If you need copper tube that can be bent easily, and offers you as well the advantages of corrosion resistance, high heat transfer, easy joinings, see Revere. We also make copper pipe, tube in copper alloys, aluminum alloys, and electric welded steel tube. If required, the Technical Advisory Service will gladly collaborate with you, as it has with Rome-Turney, on selection and specification matters. Get in touch with the nearest Revere Sales Office.

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Product Engineering

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THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

Member of Associated Business Publications and Audit Bureau of Circulations

Published monthly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. **Publication office, 99-129 North Broadway, Albany 1, N. Y.**

Executive, Editorial and Advertising Offices: McGraw-Hill Building, 330 W. 42nd St., New York 36, N. Y. Donald C. McGraw, President; Willard Chevalier, Executive Vice-President; Joseph A. Gerardi, Vice-President and Treasurer; John J. Cooke, Secretary; Paul Montgomery, Senior Vice-President, Publications Division; Ralph B. Smith, Vice-President, Editorial Director; Nelson Bond, Vice-President, Director of Advertising; J. E. Blackburn, Jr., Vice-President, Circulation Director.

Subscriptions: Product Engineering—Subscription Service, 99-129 N. Broadway, Albany 1, N. Y., or 330 W. 42nd St., New York 36, N. Y. Allow one month for change of address.

Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

Single copies 50c. United States and possessions, $5 for one year, $8 for two years, $10 for three years; Canada, $6 for one year, $10 for two years, $12 for three years; Latin American countries: $15 for one year, $25 for two years, $30 for three years; all other countries, $25 for one year, $40 for two years, $50 for three years. Entered as second class matter Aug. 21, 1936, Albany, N. Y. Post Office, under act of Mar. 3, 1879. Printed in U. S. A. Copyright 1953 by McGraw-Hill Publishing Co., Inc.—All rights reserved.

Number of copies printed this issue 28,628

THIS MONTH'S COVER

Perhaps one of the most active industrial fields from both the design and application standpoint is that represented by rotating control elements. The photograph on this month's cover showing some of the newer types introduces a series of two articles, the first of which starts on page 129. A subsequent article early next year will treat mechanical and hydraulic devices in detail.

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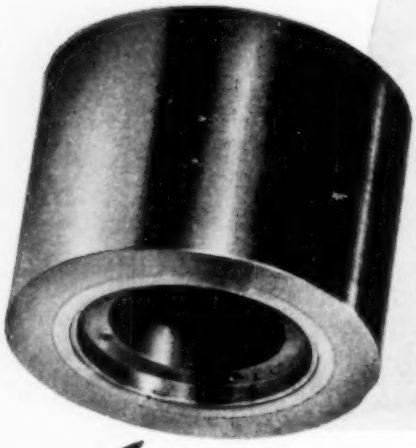
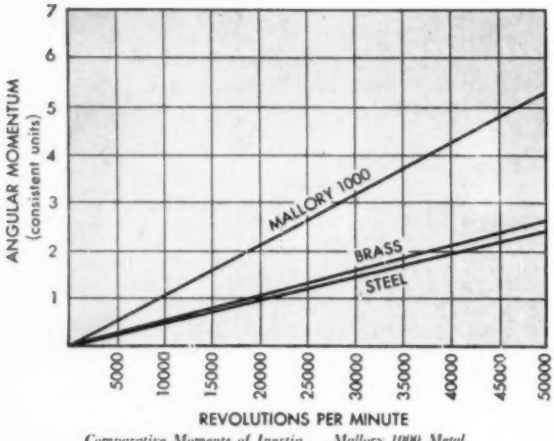


Identical in Size and Shape...

Yet this gyroscope rotor is *twice* as heavy as this one

WHY? Because the heavy one is made of Mallory 1000 Metal, an extremely dense tungsten base alloy, weighing 16.96 grams per cubic centimeter—compared to 7.87 for steel.

The curve shows the more than double inertia forces that can be obtained when steel or brass rotating inertia members are replaced by Mallory 1000 Metal. Gyroscope capacity can be greatly increased without the expense of redesigning or retooling the instrument . . . and without increasing its size.



Comparative Moments of Inertia . . . Mallory 1000 Metal, Brass and Steel. Identical sizes and rotational speeds.

In addition to high density, Mallory 1000 Metal also has these outstanding advantages:

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- Mallory 1000 is easy to machine. It is similar to gray iron in both performance and chip form.

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear.

NONMETALLIC MATERIALS

. . . . A zinc-rich paint, designated ZRC, has been developed by the Sealtube Co., Wakefield, Mass., to prevent metal corrosion. The paint has a metal content of 93-95 percent, and it is claimed that the paint can be used either as a primer or to touch up corroded areas of new or existing metal structures.

NON-FLAMMABLE HYDRAULIC FLUID . . . .

. . . . For use in hydraulic equipment operated near open flames or adjacent to extreme heat, this hydraulic fluid is non-toxic and non-corrosive. E. F. Houghton and Co., Philadelphia, Pa., reports the fluid will not freeze and can be pumped at temperatures down to 0 F. Fluid is claimed not to attack synthetic rubber packings and is resistant to viscosity change at varying temperatures. Strength tests indicate it will carry 2½ times the load of conventional hydraulic oils of similar viscosity. Pump pressures of 1,000 psi can be used.

NEW MICARTA . . . .

. . . . A new grade of laminate, designed to utilize glass mat reinforcement, has been developed by Westinghouse Electric Corp. Outstanding properties claimed for this type are good electrical insulation qualities and excellent moisture resistance with toughness and high impact strength. Moisture absorption is 0.35 percent for a ⅛ in. thick panel.

METHYSTYRENE . . . .

. . . . Experimental quantities of this material are being manufactured by a recently developed process that is claimed to give plastics and resins a greater heat resistance. American Cyanamid Co., N. Y., reports that toluene is reacted with acetylene, and the derived chemical subjected to catalytic cracking to produce methystyrene. Polymers produced from methystyrene are said to show significant properties for injection molding compounds, surface coating resins, and low pressure laminating compounds of greater heat resistance than other known polymer produced plastics.

LOW COST ADHESIVE . . . .

. . . . An adhesive that is said to allow very thin films of vinyl to be laminated to cloth and paper is a development of the Pioneer Latex and Chemical Co., Middlesex, N. J. The materials can be joined at very low pressure, which eliminates stretch marks, unevenness and sag that usually exist with thin film laminates. A minimum of heat is required for drying.

CERAMIC FOR NICKEL . . . .

. . . . A successful method for coating commercial nickel with a ceramic has been developed in the Oak Ridge National Laboratory. The new method first anneals the nickel in water saturated hydrogen at 1,000 F. The annealed material is then sprayed with an NBS ceramic coating, A-418, dried and fired. Tested by heating in an oxidizing temperature at 1,500 F for 65 hr, the coating still had a good appearance and showed improved adherence over other coatings.

METALLIC MATERIALS

. . . . A bearing steel that has excellent performance up to 500 F and that has shown no deterioration at 900 F after 100 hr is a development of Bower Roller Bearing Co., Detroit, Mich. The steel, a Ni-Ch-Mo carburizing grade, minimizes the problems of annealing and machining a high carbon steel.

HYDRAZINE FLUXES . . . .

. . . . Alumin ım, as well as other metals, can now be soldered reliably and safely in production with the use of hydrazine fluxes. The fluxes are non-corrosive, leave little or no residue and are harmless to personnel. The McCord Corp. and the Ford Motor Co., Detroit, Michigan, have used hydrazine on over 2,000,000 copper and brass automotive heat exchangers with excellent results. Tried on aluminum radiators, the flux was found to be satisfactory whether aluminum was being soldered to aluminum or to brass or copper.

HIGH TEMPERATURE ALLOYS . . . .

. . . . A research program to develop alloys suitable for service above the 2,100 F range is to be undertaken by the Battelle Memorial Institute. Objectives are to provide either mechanical and corrosion resistant properties better than obtainable with present alloys, or to achieve equivalent properties with alloys of lower strategic alloy content than is now possible.

(continued on page 7)

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with GUARDIAN® *Relays*

THE SWITCH IS ON to Guardian Relays, Steppers, Solenoids and Contactor units to improve the performance of business machines that count and compute, as well as a variety of devices that sort—control time intervals—establish sequence operations—convey—package—vend—meter and mail. Here, Guardian's precision design and mass production techniques gained through three wars meet again on the homefront to bring unparalleled quality into electrical control circuits. The Guardian No. 1 A.C. Solenoid is appropriately the No. 1 choice of leading manufacturers of adding machines. The Guardian Series 595 Relay is widely used by manufacturers of adding machines and card computing devices. It is small, compact and low in cost. Available with open type construction (up to 4 P.D.T.) or *hermetically sealed* to specification. Send blue print for a prompt quotation and specific recommendations.

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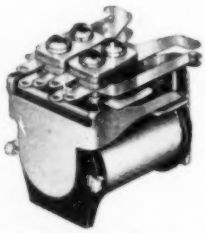

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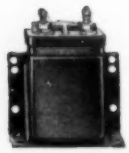

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Highlights ~

ZIRCONIUM STRIP . . . .

. . . . Hafnium free zirconium strip is presently being rolled by Allegheny Ludlum at its Watervliet, N. Y. mill. Current production is pegged at 120,000 lb per year. The sponge for this material is still being produced by the Bureau of Mines by a method developed at the Oak Ridge Laboratories of the A.E.C.

GERMANIUM IN ASH . . .

. . . . Germanium has been found in the ashes of certain American coals in sufficient quantity to permit economical recovery. This is reported in Circular 272 published by the U. S. government, Washington, D. C. At present, the major source of American germanium is as a byproduct from the refining of zinc ores.

COMPONENTS

. . . . A tubular-shaped capacitor 1/8 in. dia and 5/16 in. long is expected to help in the development of miniature radios and electronic devices. G. E. Capacitor Department, Hudson, N. Y., designed the unit as a companion to the transistor; it can be applied, in many instances, in equipment using transistors. The capacitor is made of silver and tantalum metals.

STAINLESS CLAMP . . . .

. . . . Stainless steel clamps for use in high temperature locations are a design of Thomas Associates, Los Angeles, California. Wrapped with spun glass cushioning material, they resist temperatures up to 1,200 F, as shown by a 70 hr test. Little change was noted except for a slight flaking of the paint. After application of the spun glass, the units are dipped in a special aluminum and silicate base paint for a binder.

PROTECTION SYSTEM . . . .

. . . . A system for protection against excessive temperatures in many types of industries has been developed by Thomas A. Edison, Inc., West Orange, N. J. The equipment is a temperature indicating and alarm device that can be installed without taking needed control panel space. The system is claimed not to use electronic tubes and moving parts and will immediately identify the trouble point.

FINE MEASUREMENTS . . . .

. . . . A device that measures variation in the thickness of paper down to 5 millionth of an inch using ordinary air under pressure has been developed by the Roanwell Corp., Brooklyn, N. Y. The company claims that the instrument will give makers of metal foil, plastic sheeting, and other manufacturers a continuous check on the thickness of their products.

CARBIDE TIPPED SAW . . . .

. . . . A double-bevel, carbide tipped saw has been designed for cutting laminates and double-faced veneers by Lemmon and Snoap, Grand Rapids, Mich. Two years of field testing indicate that the saw will cut without tearing or chipping surfaces of double-faced panels as occurs when cutting plastics.

TWIN CATHODE RAY TUBE . . . .

. . . . For trace comparison studies, a seven inch tube dual-channel oscilloscope has been designed by Electronic Tube Corp., Philadelphia, Pa. The unit is said to feature larger display, higher sensitivity and closer tolerance. The tube can present two traces simultaneously for fast, accurate comparative studies of independent phenomena for test or research.

RUBBER CHEMICAL . . . .

. . . . A rubber chemical that is claimed to aid the processing of natural and many synthetic rubbers has been developed by the Thermoid Chemical Co., Trenton, N. J. Production time is reported reduced, and processing temperatures lowered. These advantages are obtained without sacrifice of the physical properties of the cured article and at reduced cost.

PROCESSES

. . . . Widths up to 24 in. can now be rolled without intermediate annealing from 0.080 in. to 0.0025 in. thicknesses using a new Sendzimer rolling mill. Chase Brass and Copper Co., Inc., Cleveland, Ohio, reports that such strips can be used for making honeycomb and lock-seam tubes for automobile heaters and radiators and for shim stock. The strip has an improved surface finish, few irregularities, and a higher luster than strip rolled on other mills. By means of lateral roll adjustments, better strip flatness is also obtained and uniformity of thickness improved.

HOMOGENEOUS TITANIUM ALLOY . . . .

. . . . A technique for the production of titanium alloy by a double arc melting method has been developed by Armour Research Foundation, Chicago, Ill. An electric arc furnace using a non-consumable

(continued on page 9)

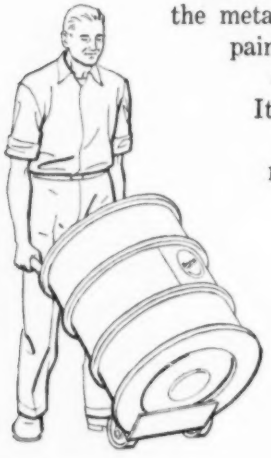
Wonder chemical

CHANGES METAL SURFACES, MAKES PAINTED PRODUCTS *look better longer*

NOT ALL "wonder chemicals" are new! Here's one that for more than a score of years has been doing a job that manufacturers at first said couldn't be done.

In as little as sixty seconds, Bonderite changes the surface of metal parts to a *nonmetallic* layer of unusual properties. Bonderite is used on automobile bodies, refrigerator cabinets, transformers, hardware, and metal furniture, to name a few items out of thousands.

This nonmetallic coating does several amazing things. Because it has an affinity for organic coatings and is integral with the metal, it takes and holds paint securely, preventing chipping and peeling. It acts to keep moisture from reaching the metal, thus controlling rust and corrosion. And should the paint film be damaged by accidental scratch or dent, Bonderite prevents the spread of finish failure.



All of these benefits combine to mean lasting fine appearance for those thousands of products whose manufacturers use Bonderite before painting.

Unlike many "wonder chemicals," Bonderite requires no special handling. It produces excellent results in large and small installations, in spray and immersion applications, and on steel, aluminum, zinc, or cadmium and their alloys.

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corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces

electrode melts titanium sponge to provide an ingot that can be forged into a rod. The rod is remelted as an electrode in a consumable electrode furnace, and a homogeneous continuous cast ingot is obtained. The crucible in which the second ingot is formed is a ¼ in. wall copper tube enclosed by a brass water jacket. Double melted ingots weighing up to 200 lb are produced from the following alloys: 2 and 6 percent Al; 6 percent Al-1 percent Si; 8 percent Al-1 percent Si.

WRINKLES REMOVED FROM ALUMINUM . . . .

. . . . Parts formed from aluminum sheet by the rubber pad method frequently wrinkle. This has been partly overcome at North American Aviation Inc., Los Angeles, Calif., by attaching a clip to one edge of the blank. As the rubber pad is forced down against the clip, the aluminum sheet is formed to the configuration of the die. At the same time, the clip is forced to back off the aluminum, but in doing so, maintains sufficient tension to eliminate wrinkles.

TANTALUM STRIP . . . .

. . . . Development work on precision rolled, close tolerance tantalum strip has been completed by the American Silver Co., Inc., Flushing, N. Y. Tantalum can be custom rolled in strip up to 6 in. wide and down to 0.005 in. in thickness, to tolerances as close as ±0.0001 in. The material is an extremely nonmagnetic and corrosion resistant metal, with tensile properties comparable to cold-rolled steel.

TESTING

. . . . Rapid measurement of the conductivity of nonferrous materials can be made using a new instrument developed by the Magneflux Corp., Chicago, Ill. Applications include the absolute conductivity of material; sorting of mixed lots of metals and alloys; and the relationship between conductivity and other physical properties, such as how conductivity varies with temper in aged aluminum alloy. Measurements are independent of material thickness, provided the material is thicker than the depth of penetration of the eddy current induced by the probe.

GAS TURBINES . . . .

. . . . Experimental installations are to be made to operate a gas turbine on blast furnace gases, according to the British Iron and Steel Research Association. Since the turbine can burn furnace gas directly, it provides instant power. It is also believed the hot exhaust gases of the turbine might be used to heat blast furnaces, which would save about 10 percent of the blast furnace gas produced. In addition, the turbines might eliminate the need for Cowper stoves, and could be linked with alternators to generate electric current for other phases of the work.

NON-MAGNETIC TEST CHAMBER . . . .

. . . . For determining the effects of temperature on electrical fields in development testing of pure metals, this chamber has a range of minus 112 to plus 68 F. Bowser Technical Refrigeration Corp., Terryville, Conn., reports that electrical apparatus are located far enough away to eliminate effects of their magnetic fields. The cabinet itself is made of non-steel construction; special inner chamber, governed by vernier control, holds temperature to plus or minus 0.1 F.

VELOCITY OF LIGHT EXCEEDED . . . .

. . . . Using an oscillographic and photographic combination instrument, called a time microscope, that records very rapid voltage changes and permits the observation of phenomena of relatively brief duration, a spot of light was measured at 202,000 mps. The Naval Research Laboratory claims the instrument will make possible the study of electrical events which occur in one millionth of a millionth second.

ALUMINUM CORROSION . . . .

. . . . A review of weathering tests over a 25 year period has led Alcoa to the following conclusions. Alloys 2S, 3S and 4S have essentially the same high resistance to corrosion while 52S is almost as good. Not quite as good are such alloys as 61S. Alloys containing large amounts of copper, 14S. 17S, 24S, or large amounts of copper, zinc and magnesium, 75S, do not have good corrosion resistance. The tests tend to prove that wrought and cast aluminum alloys and Alclad are suitable for use as outdoor structural materials in industrial sea coast and tropical areas.

HIGH CASTING ALLOYS . . . .

. . . . An extensive research project into high alloy castings has been set up by the Alloy Casting Institute's technical committees. One project, a continuing study of casting corrosion under pressure and high temperature, will be conducted at Ohio State University, Columbus, Ohio. Commonly used alloys of the 18-8 type and high nickel grades are to be investigated in a variety of corrodents such as, sea water, chemical solutions, steam and others. Modifications of the stainless steel and high nickel alloys will be studied too. As a result of the studies, the researchers hope to develop improved corrosion resistance and methods for inhibiting corrosive attack when they are subjected to high temperatures or pressures.

LOOKING FOR CORROSION RESISTANT MATERIALS?

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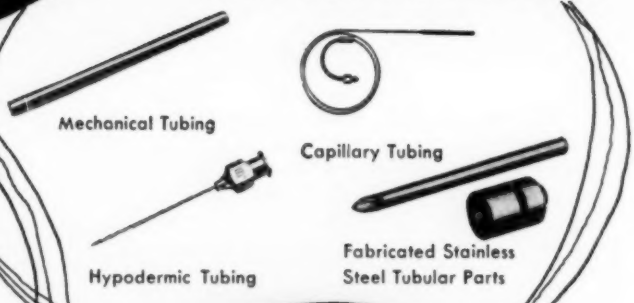

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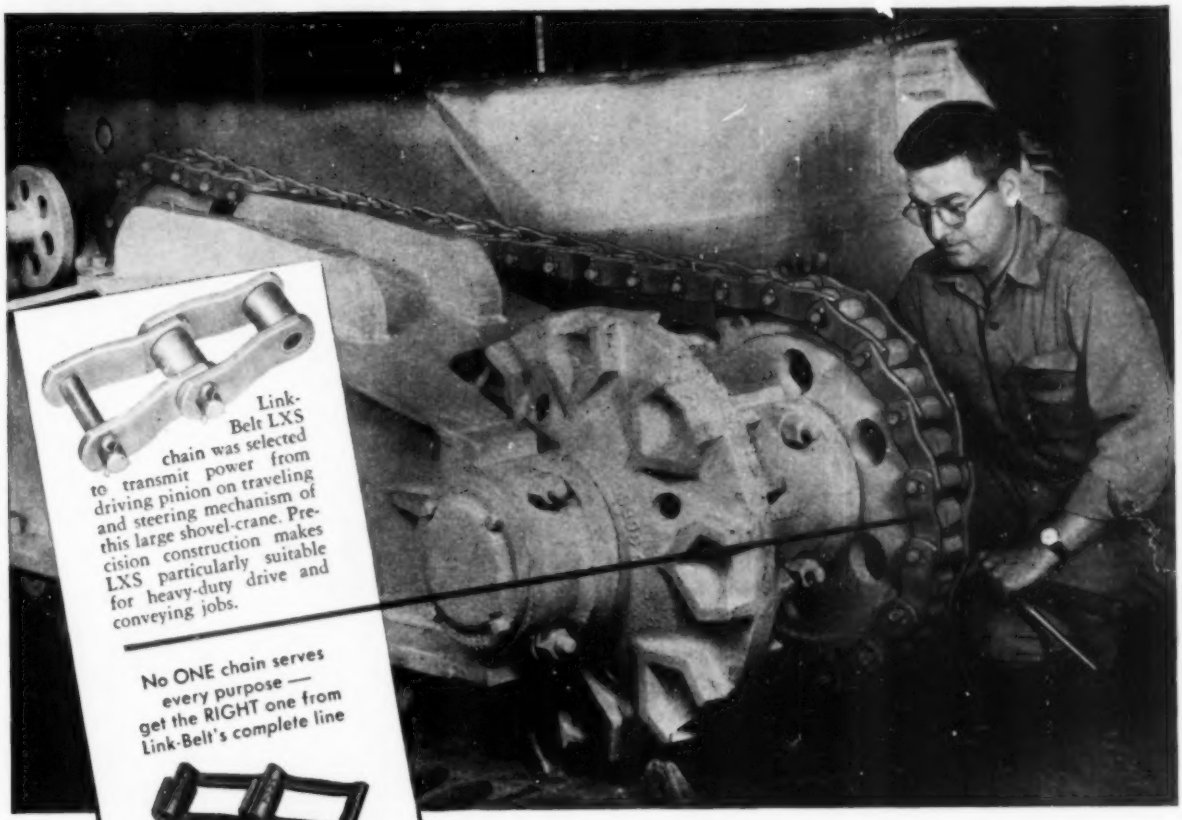
J. BISHOP & CO. Platinum Works

Malvern, Pennsylvania

For long chain life under severe drive or conveyor service . . . it's

LINK-BELT LXS



Link-Belt LXS chain was selected to transmit power from driving pinion on traveling and steering mechanism of this large shovel-crane. Precision construction makes LXS particularly suitable for heavy-duty drive and conveying jobs.

No ONE chain serves every purpose — get the RIGHT one from Link-Belt's complete line

Steel Link-Belt for moderate-strength power transmission and conveying. Also available in malleable.

Class C combination chain—popular, durable, low cost design for elevators, conveyors.

Class H Pintle chain—excellent for conveyors that slide because of broad wearing surfaces.

Class 400 Pintle chain—closed end design keeps out dirt, makes excellent service medium for drives, elevators, conveyors.

LINK-BELT offers the chain that's best for every job

Here's a fabricated steel roller chain that outlasts, outperforms ordinary chain where the going is tough. Accurate sizing of full-round pins, bushings and pitch holes assures users of Link-Belt LXS chain closer joint fit . . . better wear resistance.

Manufacturing refinements such as these are typical of every chain in the complete Link-Belt line. Accurate control of raw material specifications and manufacturing processes results in uniformity . . . longer chain life.

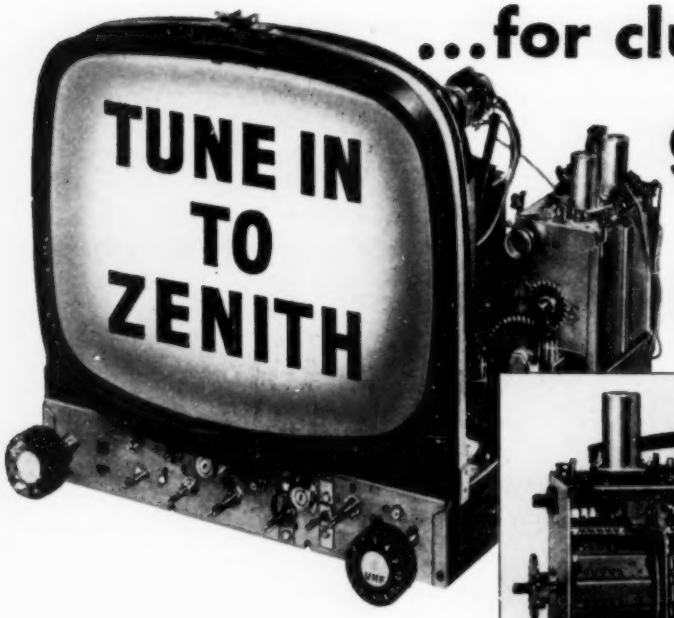
For all the facts on LXS chain, and for information on the complete line of Link-Belt chains and sprockets, see the Link-Belt sales representative nearest you.

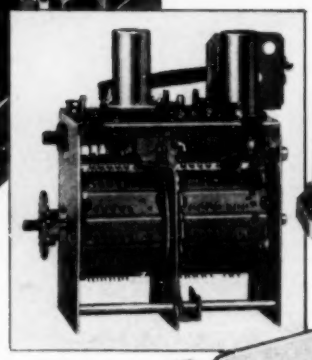
LINK-BELT

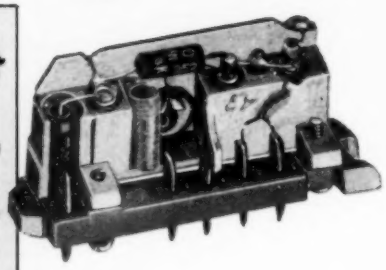
CHAINS & SPROCKETS

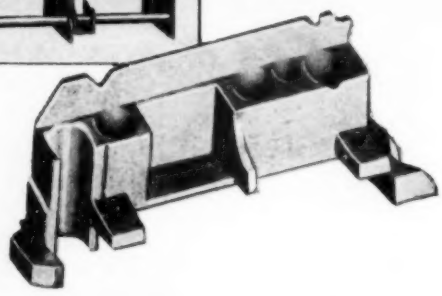
LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Sydney; South Africa, Springs. Representatives Throughout the World. 13.340

...for clues to get the mo$t for your Zinc Die Ca$ting Dollar!









The biggest savings achieved by the die casting process are not always found in the biggest castings. At the right you see a ZINC Die Casting measuring only 2⅛ inches long but embodying king-sized economies. Die casting is the only economically feasible method of producing this part in one piece, *and ZINC is the best-suited metal.* It is a tuner strip frame used in converting existing Zenith TV Turret Tuners from VHF (very high frequency) to UHF (ultra-high frequency). A separate strip is used for each channel.

Only two simple reaming and tapping operations are required to prepare this complex ZINC Die Casting for assembly. The die caster, working closely with Zenith engineers, incorporated in the casting all of the openings, recesses and holes required for the assembly of the delicate "innards" of the tuner strip.* The design is one which calls for irregular distribution of metal from feather edges to heavy mounting sections—all with extremely close tolerances. *The unusual castability of ZINC alloy makes this the preferred metal for such die casting applications.*

Many other current examples of die casting economies can be found in our new booklet "The End Uses of Zinc Die Castings." Ask us—or any commercial die casting company—for a copy.

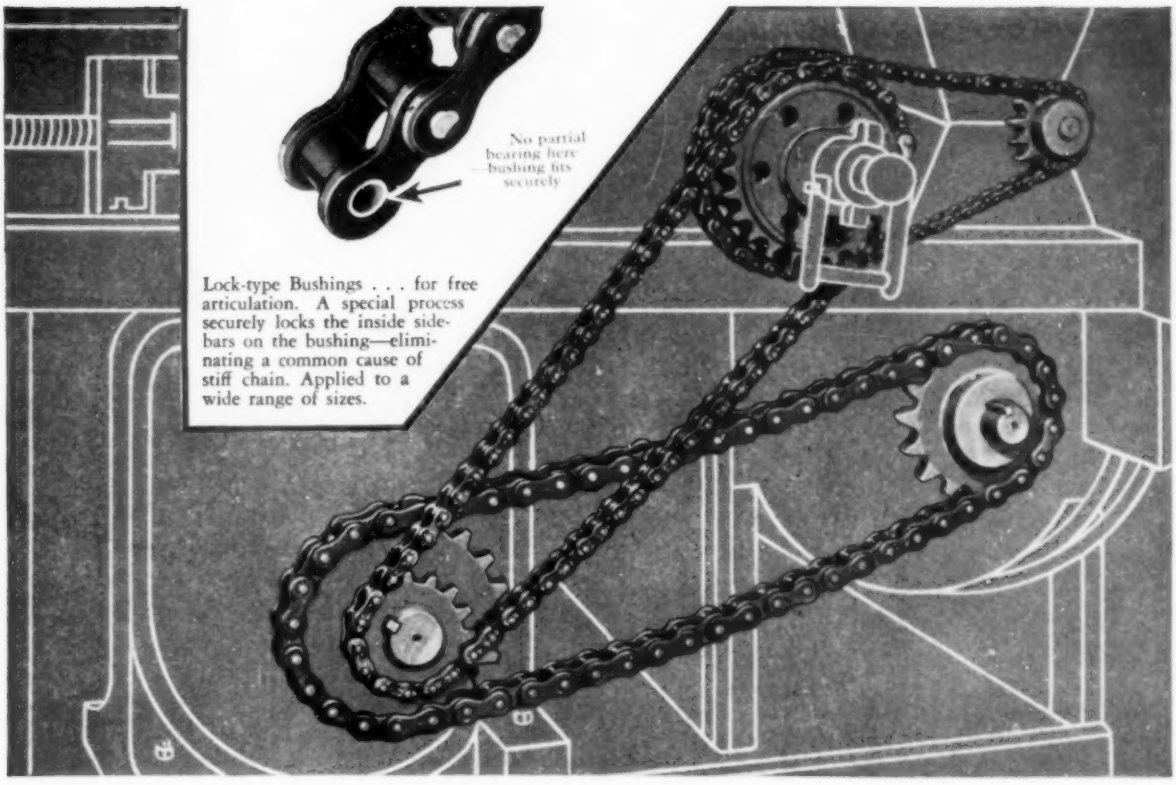
Send for your copy

** The casting is silver plated to facilitate the soldering of the many wires used in the assembly.*

The New Jersey Zinc Company
160 Front St., New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC


No partial bearing here—bushing fits securely
Lock-type Bushings . . . for free articulation. A special process securely locks the inside sidebars on the bushing—eliminating a common cause of stiff chain. Applied to a wide range of sizes.

Look to LOCK-TYPE BUSHINGS for longer roller chain life

Just one of many engineering extras you get from LINK-BELT

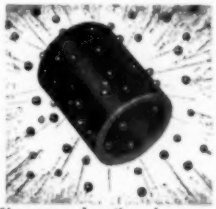
FOR drives that must operate under severe conditions, it will pay you to use Link-Belt Precision Steel Roller Chain. Lock-type bushings and the many other Link-Belt engineering extras add up to *built-in* extra life. Whether it's for power transmission or conveying, you are assured of a positive, flexible, economical chain . . . with high sustained efficiency. For complete information, see your nearby Link-Belt sales representative, or write for Engineering Data Book 2457.

LINK-BELT

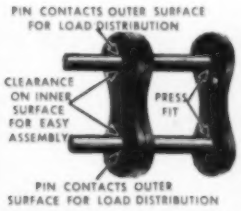
ROLLER CHAINS & SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,350-B

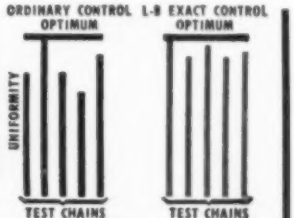
Don't overlook these other LINK-BELT extras



Shot-peened rollers have extra fatigue life under impact.


PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION
CLEARANCE ON INNER SURFACE FOR EASY ASSEMBLY
PRESS FIT
PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION

Couple and uncouple multiple-width chains more easily.



Closer heat treat control helps attain greater uniformity.

What's Screwy? by Phillips

"Nope! Not more than 3 Phillips Recessed Head Screws for the lot. After all, it's only ivory."

PERFECTLY MATED! Only Phillips Drivers are perfectly mated to Phillips Screws. Look for the name Phillips on the shank.

SALES VALUE is only one of many advantages added to your product when you use Phillips Screws. These screws also save money, work, time. They eliminate driver skids, damaged parts and split screw heads. They cut driving time up to 50%. And they set up tighter having a maximum strength of head due to their design. For best results, choose Phillips Wood, Machine, Tapping Screws or "Sems."

PHILLIPS *Cross-Recessed-Head* **SCREWS**

X marks the spot... the mark of extra quality

AMERICAN SCREW COMPANY • ATLANTIC SCREW WORKS, INC. • THE BLAKE & JOHNSON CO.
CENTRAL SCREW COMPANY • CONTINENTAL SCREW COMPANY • THE EAGLE LOCK COMPANY
ELCO TOOL AND SCREW CORPORATION • GREAT LAKES SCREW CORPORATION • THE H. M. HARPER CO.
THE LAMSON & SESSIONS COMPANY • NATIONAL LOCK COMPANY
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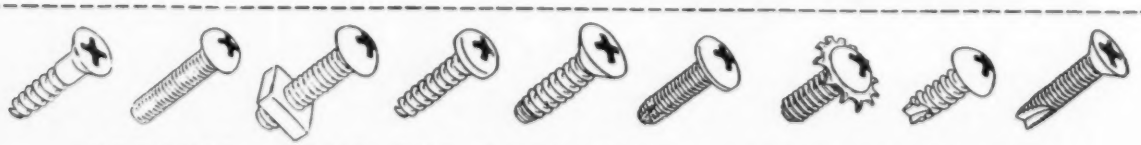
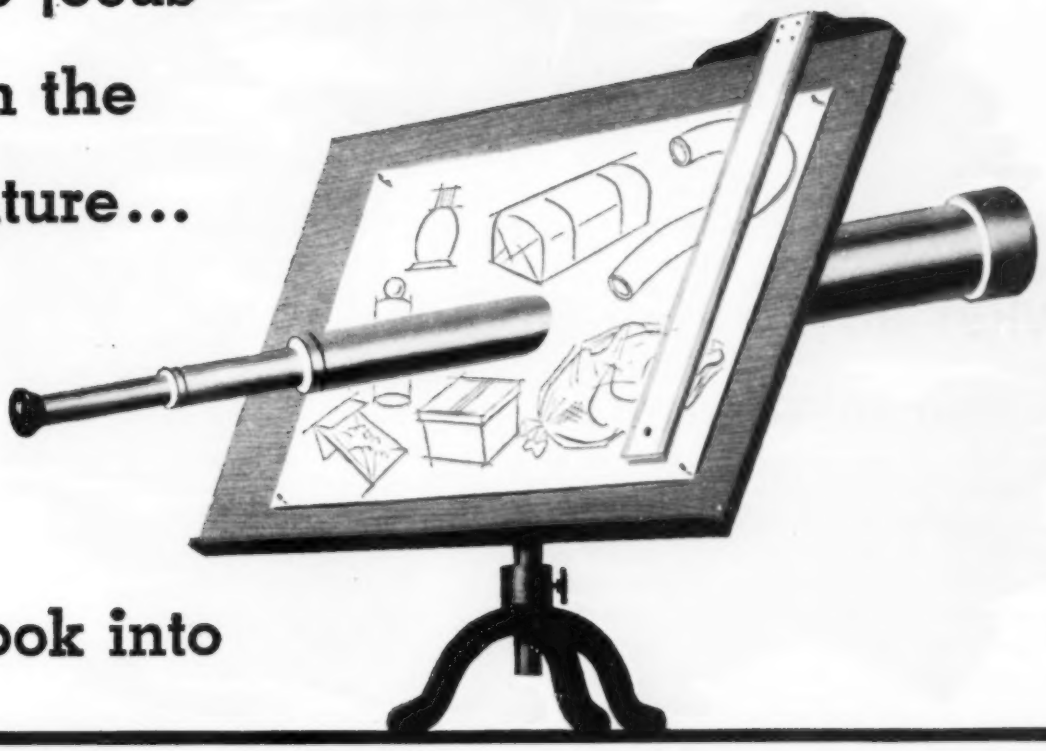
SHAKEPROOF DIV. OF ILLINOIS TOOL WORKS • THE SOUTHINGTON HDWE. MFG. COMPANY
STERLING BOLT COMPANY • WALES-BEECH CORP.



TODAY'S... AND THE FUTURE'S... FINEST FASTENER

To focus on the future...



Look into

BAKELITE TRADE-MARK **Polyethylene**

YOU'LL MAKE TOMORROW'S NEW PRODUCTS COME CLOSER

THE THINGS this plastic can do . . . the many ways it can be used . . . will stir the imagination of designers and manufacturers like no other plastic before.

Products lingering on drawing boards, or in idea-pending files for want of the *right* material, may now be projected into wonderful new products that can dominate tomorrow's markets.

There's hardly an industry, or a product that cannot benefit in some new, exciting way from the remarkable combination of properties of this dynamic new plastic . . . whose uses and demand are growing by leaps and bounds.

Focus your sights on the future now. Let the power of BAKELITE *Polyethylene* expand your ways and means to make more, newer and better products. Though it has been in short supply, new plants are now under construction to expand production. Time your own development work so you will be ready to benefit in the future.

START TODAY

Write for the free new 24-page booklet, BAKELITE *Polyethylene* that will show how *you* can benefit. Write Dept. SB-10,

BAKELITE TRADE-MARK **Polyethylene**

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

What do YOU make that takes wire?

If you make sieves or staples, screws or screens—whatever you make that takes wire—we're pretty sure to have the kind of manufacturers wire you need. Round, flat, square . . . hard, soft, ductile . . . plain, tinned, or bright finished . . . carbon, alloy, or stainless. Altogether we produce over 400 different types of wire which are suitable for practically all everyday wire applications.

But, if you need a special kind of wire, we can supply that too. Our modern plant facilities enable us to draw wire to meet the exact specifications of a special order, and our trained metallurgists are always ready to assist you with any manufacturing problems you may have.

We've been in the wire-making business more than one hundred years, and all of our experience is at *your* service . . . to help you do an easier and better fabrication job.

If you make it of wire . . . make it of the best!

U·S·S AMERICAN MANUFACTURERS WIRE

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire.*

USS

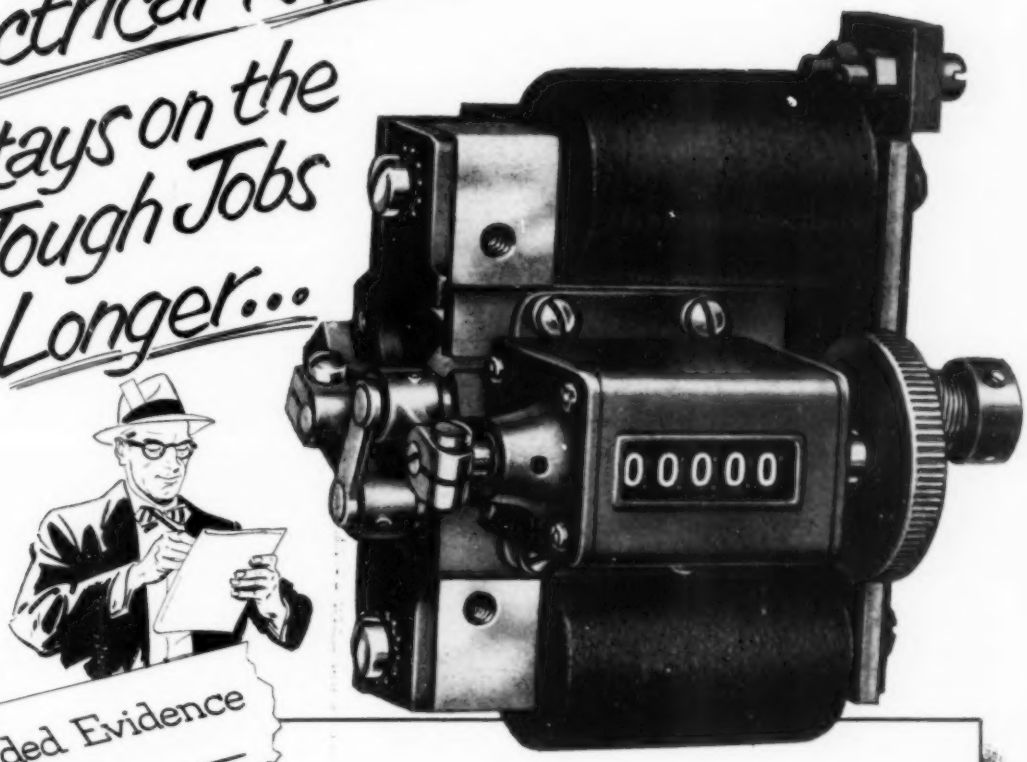
AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS

TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

This Electrical Reporter Stays on the Tough Jobs Longer...



Added Evidence that—

Everyone Can Count on VEEDER-ROOT

Compact and rugged . . . this electrically operated reset counter is specially designed for tough jobs that demand longer counter life.

Here's another instance of the *infinite applicability* of Veeder-Root *Count*rol — electrical, mechanical or manual. And here's another instance, too, of the endless resourcefulness of Veeder-Root engineering, and the ability to design a *complete counting package* that fits the job fully and exactly. Now . . . what's *your* problem?

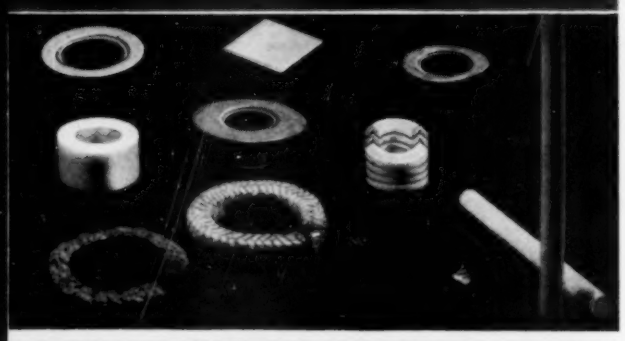
VEEDER-ROOT INCORPORATED

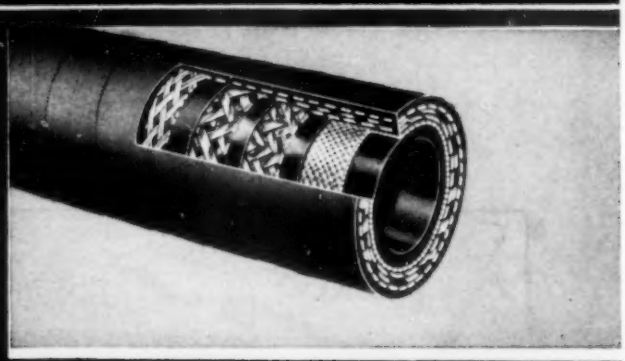
"The Name That Counts"

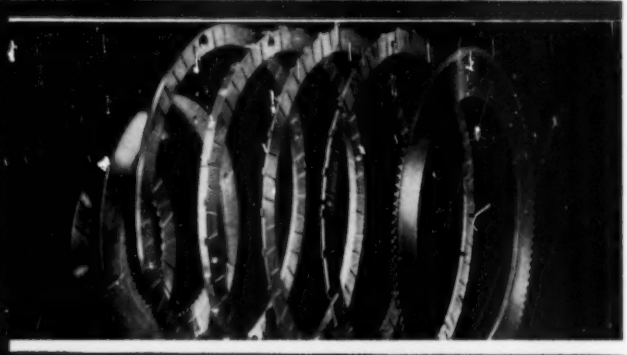
HARTFORD 2, CONNECTICUT

Chicago 6, Ill. • New York 19, N.Y. • Greenville, S.C
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

Design people find Raybestos-Manhattan engineering service helpful on problems involving Asbestos, Rubber, Sintered Metal and Teflon* Products







Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Rubber Lined and Covered Equipment

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL

To better serve you PROMPTLY.. So that R/M sales, research and engineering can best coordinate to handle your problems . . . and so that we can serve you with least delay . . . please wire, phone or write the division listed under the product in which you are interested.

PACKINGS, GASKETS
ASBESTOS TEXTILES AND TEFLON PRODUCTS

Whatever your requirements for packings and gaskets, Raybestos-Manhattan is ready to meet your needs. If, for example, you have a problem involving chemicals, an R/M Packing made of Teflon may be your answer. For Teflon is unaffected by chemicals within the temperature range of −80°F. to 500°F. The R/M line, diversified and complete, includes packings for use against air, gas, water, steam, oil, solvents, foods and hydraulic fluids. R/M is also the manufacturer of an extensive line of asbestos textiles.

**Du Pont trade-mark for its tetrafluoroethylene resin*

PACKINGS, GASKETS, ASBESTOS TEXTILES AND TEFLON PRODUCTS

Packing Division or
Asbestos Textile Division
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

MECHANICAL RUBBER PRODUCTS

Super-Master BW Steam Hose is a typical example of R/M engineering in hose design. Here is a precisely balanced burstproof construction of asbestos, non-corrosive steel wire, and cotton braid for steam pressures up to 200 lbs. per square inch and temperatures to 388°F. The basic purpose of all hose is to control fluids or gases with safety, ease and long service. Whether your problem is one of pressure, temperature, corrosion or flexibility, R/M engineering and production facilities can make the hose to give you the kind of control you want.

Wherever you have a design problem that calls for hose—or transmission, conveyor belting, V-belts, or molded rubber products—let R/M engineers work with you.

MECHANICAL RUBBER PRODUCTS

Manhattan Rubber Division
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

FRICTION MATERIALS

If you have a friction material problem, Raybestos-Manhattan can give you unbiased advice and provide you with an element engineered to your specific needs. For R/M's seven great plants and laboratories are constantly working in both the metal and asbestos fields in order to satisfy the many different industries it serves. There are countless combinations of friction materials in R/M's complete line . . . including woven and molded asbestos, semimetallic materials, and sintered metal parts.

FRICTION MATERIALS

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RAYBESTOS-MANHATTAN, INC.

Rubber Covered Rolls

Sintered Metal Friction Elements

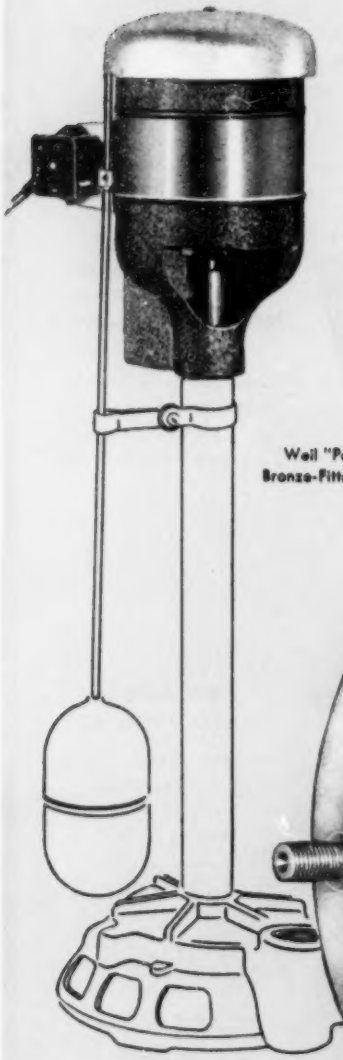
Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

AND TEFLON PRODUCTS

FACTORIES: Passaic, N.J. • Neenah, Wis. • Manheim, Pa. • Bridgeport, Conn. • No. Charleston, S.C. Crawfordsville, Ind. • Peterborough, Ontario, Can.

Manufacturers of Mechanical Rubber Products • Brake Linings • Brake Blocks • Clutch Facings • Sintered Metal Products • Fan Belts • Radiator Hose • Rubber Covered Equipment • Asbestos Textiles • Teflon Products Packings • Abrasive and Diamond Wheels • Bowling Balls

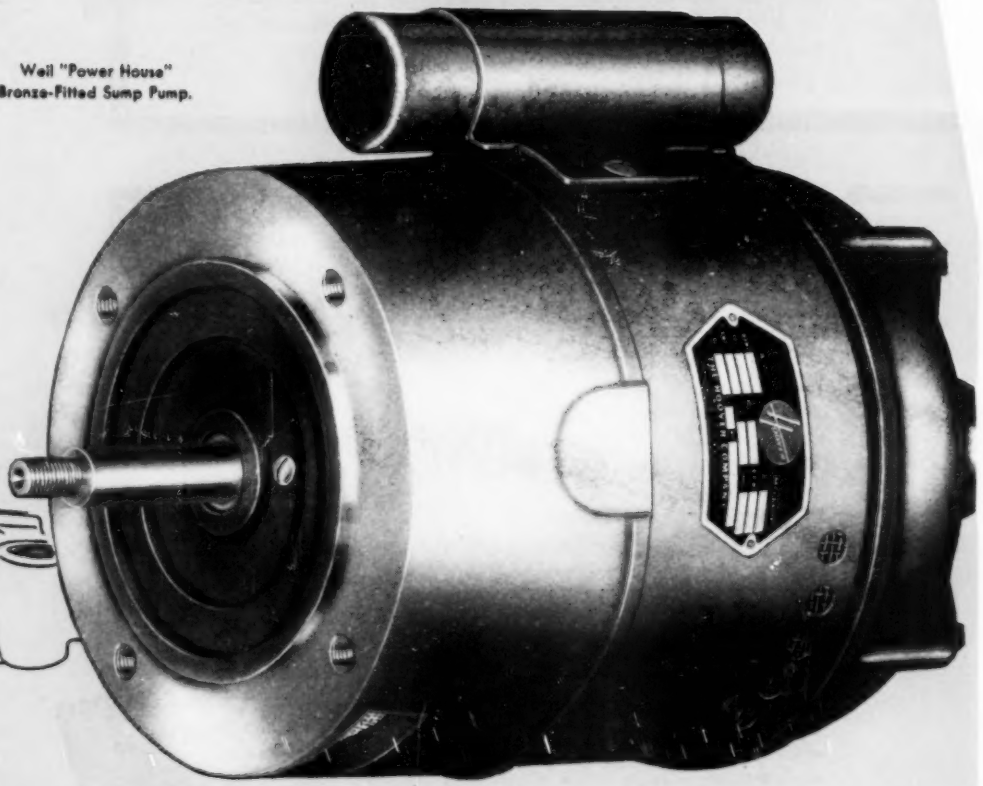


"We use Hoover Motors on many pumps, for many reasons," says Ralph Weil, Weil Pump Company, Chicago. "Because they look good. Because they run cool and have excellent bearing protection. Because the switch never requires servicing. And because Hoover backs us with such widespread service facilities."

pumps by weil

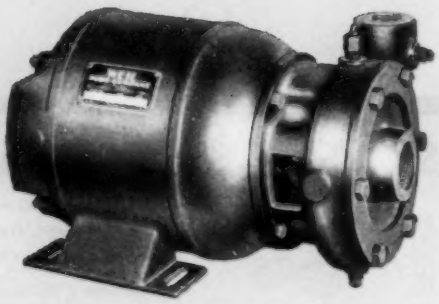
POWERED BY

Weil "Power House" Bronze-Fitted Sump Pump.



for every power need up to 5 h. p.

Weil "TVC" Condensation Pump (Single or Duplex) for Steam Mains, Water Heater Coils, Heating Systems.



Weil Close-Coupled Motor-Mounted R Pumps—for many special and built-in applications.

HOOVER

Engineering Teamwork Produces a Long and Varied Line

The pump business goes out in all directions. Weil R
pumps, for example, are used for circulating condenser
and chilled water in air conditioning systems, and for
circulating hot water in heating systems—and they're
built into washing machines, used as booster pumps for
building supply, and food, dairy and cleaning plants.
The design engineer works with the motor engineer, year
in and year out, on dozens of different applications.

This teamwork saves money—big money—on pumps and
all original equipment. When Hoover engineers are in
on the planning, they can often recommend minor
changes that permit the use of in-production models
at much lower cost. (Hoover standardized models come
in a wide and complete range with ratings up to 5 h.p.)

Or the manufacturer can outline special mechanical and
electrical characteristics, in advance, which Hoover
can work into going production lines. (Hoover
customer-tailored models usually cost less than the
buyer expects!)

Hoover engineers are at your service, all ways—to
power your product to your specifications at lowest
possible costs. And not just in original costs—
although Hoover compactness cuts material and
installation expense. Hoover starting
switches, improved insulation, full-power
performance cut electricity expense for your
customers. And Hoover's world-wide service
organization keeps maintenance costs to a
minimum. Investigate Hoover before you
specify for any motor application.

WRITE YOUR OWN TICKET

If you need a motor for standard applications, check the current Hoover catalog. If yours is a special application, talk with Hoover engineers before you set up your line. Mail this coupon now for more information—no obligation, of course.

PRODUCTION FOR HOME AND DEFENSE
Week in and week out, Hoover is producing a very substantial volume of essential materials for the Armed Forces.

THE HOOVER COMPANY
ELECTRIC MOTOR DIVISION
84 BROOK AVENUE, NORTH PLAINFIELD, N. J.

Please send me further information on Hoover Motors. I am particularly interested in motors for

_____
(indicate type of equipment)

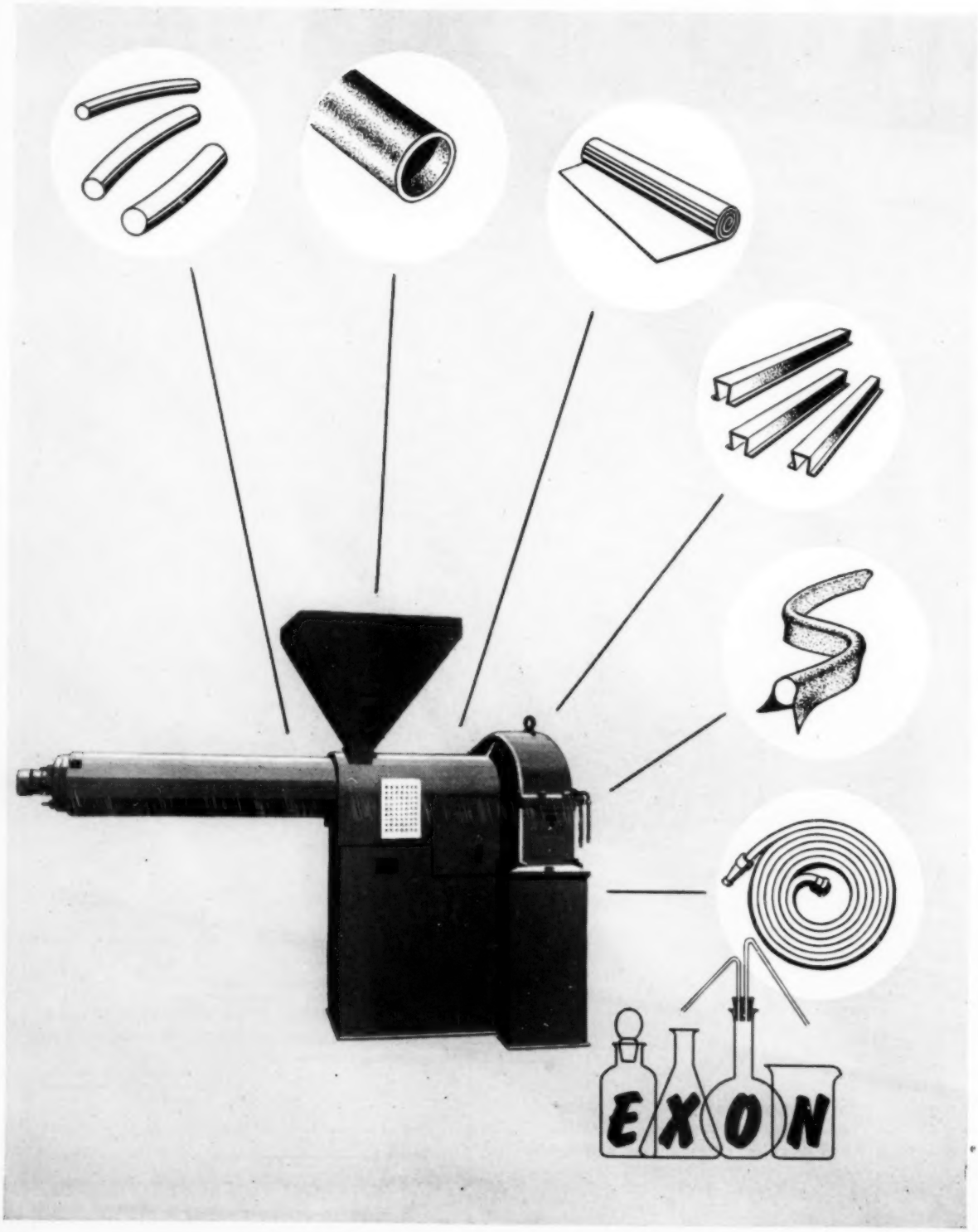
Name _____

Company _____

Address _____

City _____ Zone _____ State _____

EXTRUSIONS UNLIMITED.



...BY TEMPERATURE!

EXCEPTIONALLY VERSATILE, TEMPERATURE-TAILORED

Firestone VINYL RESINS 905-915-925

EXON

CREATE NEW HORIZONS FOR YOUR EQUIPMENT!

Extrusions as exacting as best quality garden hose are achieved with Exon 915. As an end product, it has all the desired clarity, physical toughness and resistance to aging and moisture that make your product more salable.

Exon 905's exceptional versatility makes it the choice when the ultimate in physical properties is desired.

Exon 925 is indicated when compounds are used that are low in plasticizer content and are difficult to extrude.

For final adjustments to given processing conditions, a blend of one or more of these Exon resins may be used.

With all three versatile vinyl resins, your process reaps the benefits of

- **Extremely rapid blending**
- **Shorter fusing time**
- **Freedom from "fisheyes"**

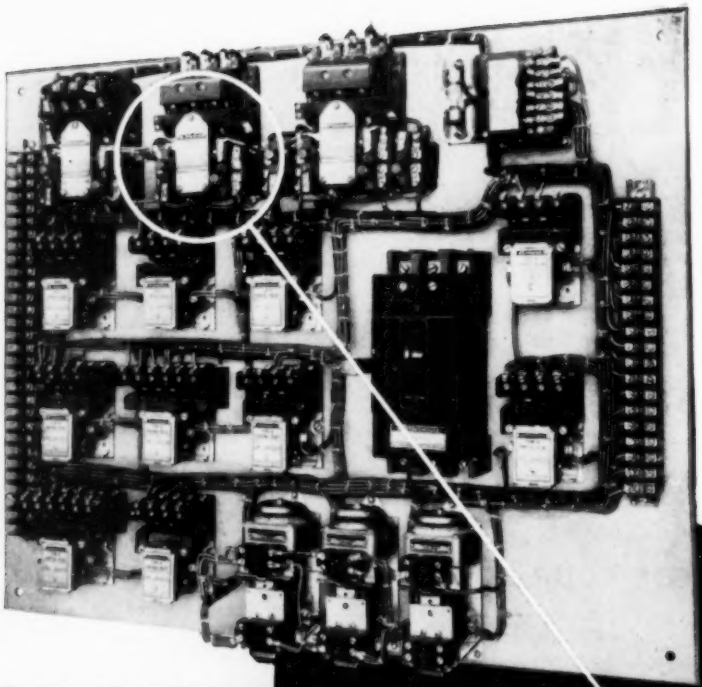
So many manufacturers who used to have temperature problems are proving the efficiency and economy of Exon resins, it would pay you to investigate how their many benefits can help you, too.

PHYSICAL PROPERTIES

	FORM	SPECIFIC GRAVITY	AVERAGE RELATIVE VISCOSITY	AVERAGE BULKING DENSITY
EXON 905 Excellent for film and sheeting applications where higher temperatures (up to 375° F.) are called for.	White Powder	1.40	2.50	0.45
EXON 915 High-versatility, resin specially designed for sheeting. Wide range of operating temperatures.	White Powder	1.40	2.30	0.45
EXON 925 An excellent P. V. C. resin for low processing temperatures. (starting at 275° F.)	White Powder*	1.40	2.05	0.45

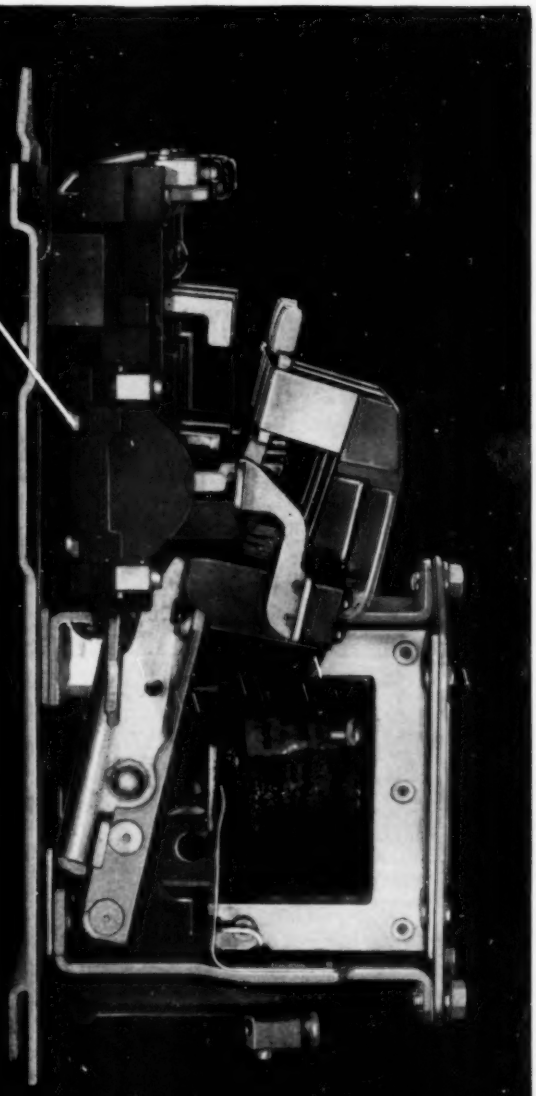
For further information on Firestone's complete line of high quality EXON resins... or for the assistance of Firestone's Technical Service, call or write:

CHEMICAL SALES DIVISION
FIRESTONE PLASTICS COMPANY · POTTSTOWN, PA., DEPT. 18P
Division of Firestone Tire and Rubber Co.



Typical special control panel with all Westinghouse components.

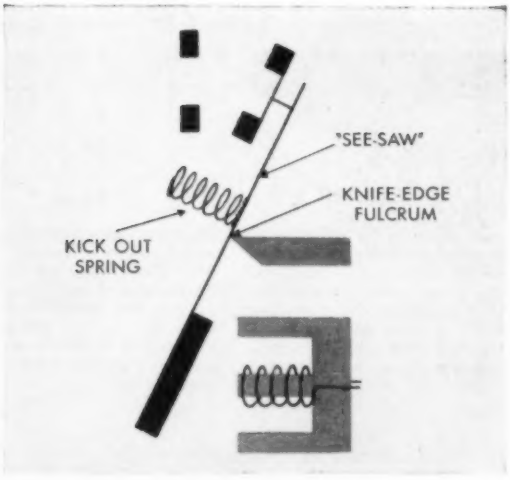
Compare the Westinghouse complete control line for any application



Westinghouse Life-Line Starter

Compare...

Simple knife-edge principle means longer life in Westinghouse *Life-Line* starters



Contact assembly is pulled against a stationary magnet—pivots on a frictionless knife-edge fulcrum. 13 years of field and laboratory testing proved the superiority of this design.

This attractive, Bonderized, general-purpose enclosure is one of many NEMA type enclosures for any industrial application. A complete line of open Life-Line Starters are available for use in machine cavities or panels.

Longer wear in the starters you buy means better performance of the machines you sell. That's why it pays to compare Life-Line Starters—for unfailing, trouble-free service over millions of operations.

Life-Line Starter has only one moving element—a "seesaw" balanced on a special knife-edge bearing. A positive kickout spring provides the contact-opening force.

This exclusive Westinghouse design eliminates two undesirable features of conventional starters: sliding members and gravity action. Life-Line's moving element is friction free—cannot stick or jam—needs no lubricating—is self-aligning. And Life-Line Starters never operate falsely due to vibration, stress or accidental impact. You can count on dependable performance on any type of machine—under any operating condition.

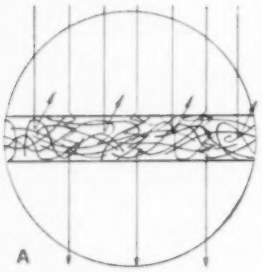
Simplified design, longer life, greater dependability—these are fundamentals of the Westinghouse complete control line—starters, relays, timers, transformers, terminal blocks, oil-tight pushbutton stations. On your machines, in your panels, Westinghouse controls mean more profit and customer satisfaction.

For complete information and application assistance on Life-Line Starters and other Westinghouse control equipment, call your Westinghouse Representative, or write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. J-30152

YOU CAN BE SURE...IF IT'S Westinghouse

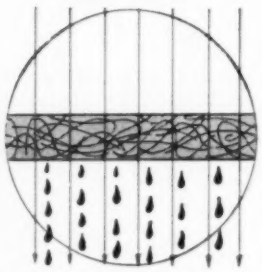
How Tracing Paper is made and why ALBANENE* is Different

TOUGH, LONG-FIBER PAPER
NOT TRANSPARENTIZED



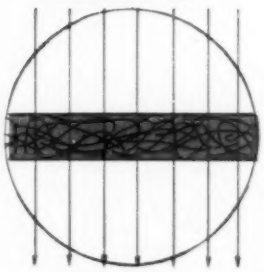
Diagrammatic enlargement of cross section of paper with high strength but low transparency. Fibers are surrounded by air, which has different index of refraction. Many light rays are bent back and do not get through.

SAME PAPER
TRANSPARENTIZED WITH FLUID MATERIAL



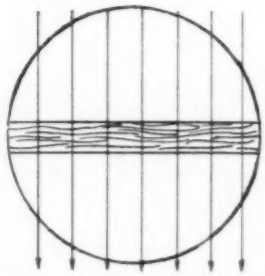
Same paper as "A", filled with oil or other fluid material, giving spaces between fibers same index of refraction as fibers. Reflection and refraction of light are reduced and paper becomes highly transparent. But transparency is not permanent because *fluids* "bleed" out.†

SAME PAPER
TRANSPARENTIZED THE ALBANENE WAY



Same paper as "A", filled with an inert synthetic resin, with correct index of refraction. This is how Albanene is made. Its transparentizer does not "bleed" out. Albanene holds its color and strength and is permanently transparent.†

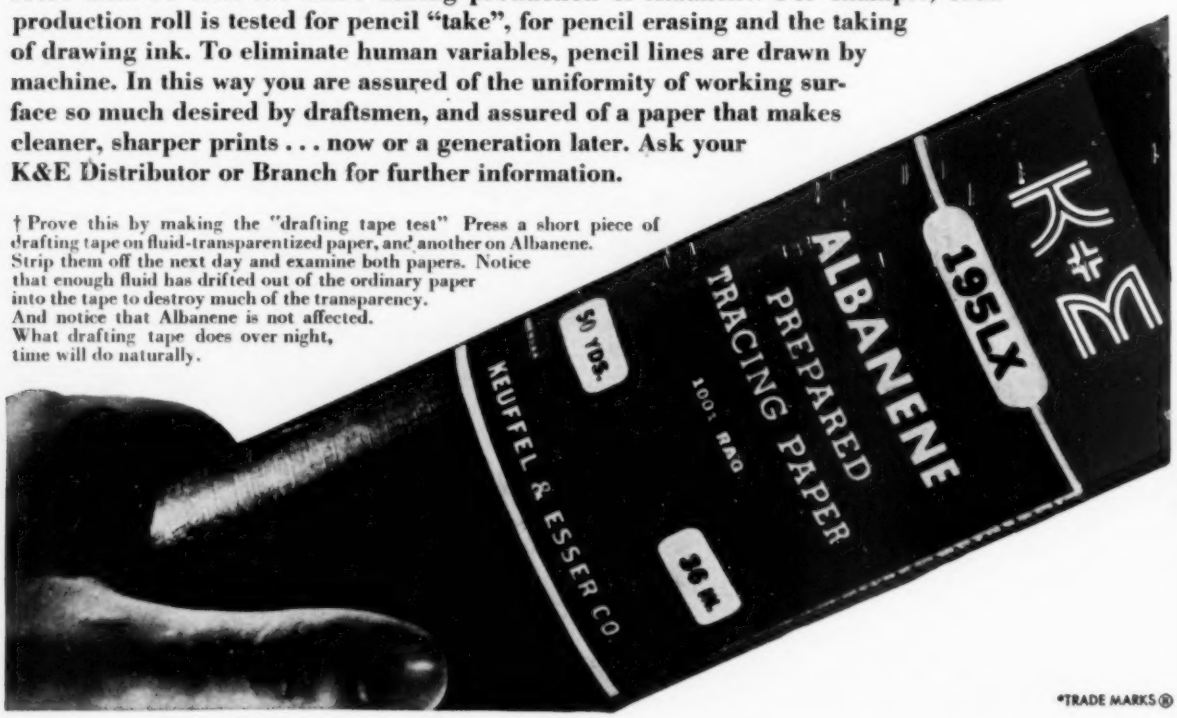
PAPER TRANSPARENTIZED BY
CRUSHING AND BEATING FIBERS



Papers are also transparentized at the mill by a "beating" process. The fibers are crushed, flattened and compacted. Reflection and refraction of light are reduced. But the process weakens the fibers and the strength of the transparent paper is low.

More than 15 tests are made during production of Albanene. For example, each production roll is tested for pencil "take", for pencil erasing and the taking of drawing ink. To eliminate human variables, pencil lines are drawn by machine. In this way you are assured of the uniformity of working surface so much desired by draftsmen, and assured of a paper that makes cleaner, sharper prints . . . now or a generation later. Ask your K&E Distributor or Branch for further information.

† Prove this by making the "drafting tape test" Press a short piece of drafting tape on fluid-transparentized paper, and another on Albanene. Strip them off the next day and examine both papers. Notice that enough fluid has drifted out of the ordinary paper into the tape to destroy much of the transparency. And notice that Albanene is not affected. What drafting tape does over night, time will do naturally.



*TRADE MARKS ®

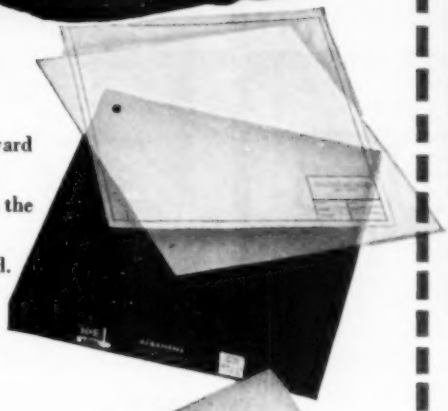
The Right Angle

Once you've discovered the pleasure of drawing on Albanene, the next logical step is to save time, trouble and eyesight with a K&E PARAGON® Drafting Machine. You control your calibrated straight edge with a light touch of one hand, for parallel lines and lines at any angle.

Make your lettering letter-perfect and save wear and tear on your nerves by using a LEROY® lettering outfit. Template grooves guide your pen so the finished result looks like printers' type, and the whole process is relaxing. There's a wide choice of sizes, styles and symbols.

AVAILABLE IN MANY FORMS FOR MANY USES

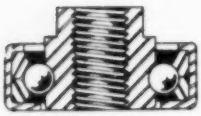
Albanene comes in 20-yard and 50-yard rolls in various widths and in three different weights. For those who like the convenience of cut sheets, a new Albanene package has been designed. It strongly protects the paper in shipment and storage, and may be opened without mutilating the container, thus serves as a dispenser in drafting room or stock room. Albanene cut sheets can be supplied imprinted to your specifications.



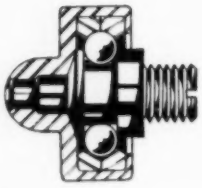
K+E

KEUFFEL & ESSER CO.

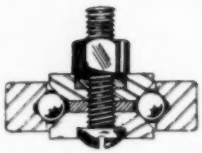
Want unusual bearing design?



Unusual? These are only a

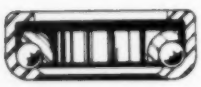


few of the many Schatz designs



available to engineers who

want to cut their costs

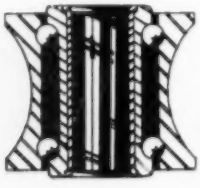


without sacrificing quality.

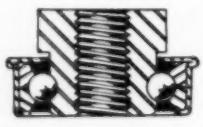
They include ball bearings

made of cold drawn parts,

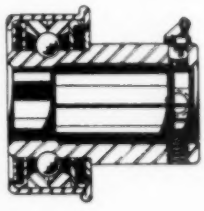
made of machined parts,



and a combination of both.

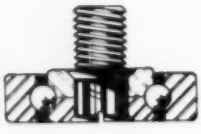


There are types suitable

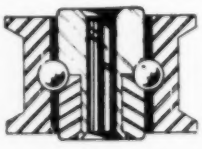


as regular ball bearings

and others as rollers.



In fact, the designs shown



here ought to suggest

many a solution to knotty

anti-friction problems.

Remember, wherever speeds and loads are moderate

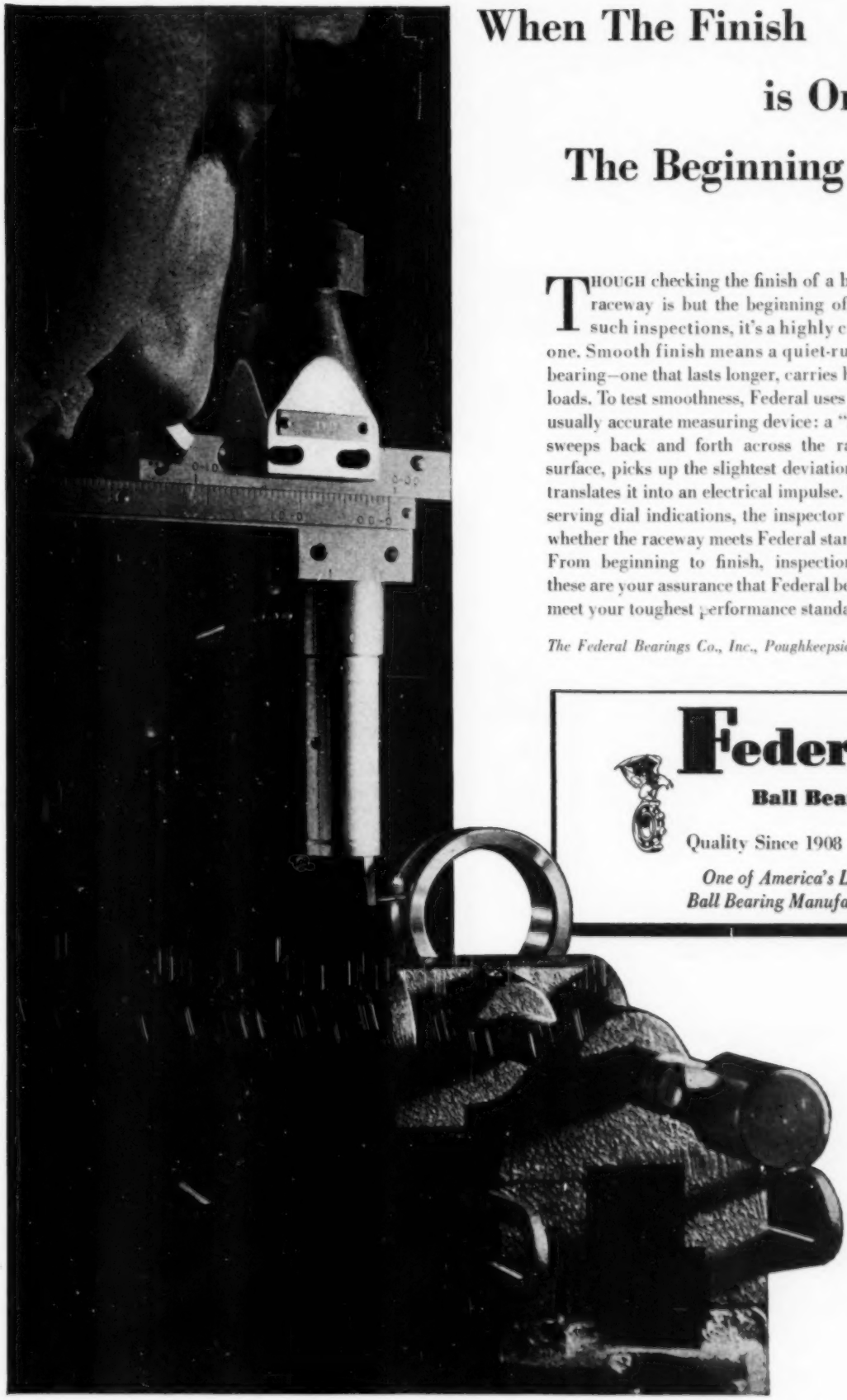
6 to 1

Schatz can often save you up to six-to-one on costs.

SCHATZ
"Commercial"
BALL BEARINGS

Get the complete story today. Write for 42-page Catalog No. 11.

The **Schatz** Manufacturing Company, Poughkeepsie, New York



When The Finish is Only The Beginning

THOUGH checking the finish of a bearing raceway is but the beginning of many such inspections, it's a highly critical one. Smooth finish means a quiet-running bearing—one that lasts longer, carries heavier loads. To test smoothness, Federal uses an unusually accurate measuring device: a "feeler" sweeps back and forth across the raceway surface, picks up the slightest deviation, then translates it into an electrical impulse. By observing dial indications, the inspector knows whether the raceway meets Federal standards. From beginning to finish, inspections like these are your assurance that Federal bearings meet your toughest performance standards.

The Federal Bearings Co., Inc., Poughkeepsie, N. Y.

Federal

Ball Bearings

Quality Since 1908

One of America's Leading Ball Bearing Manufacturers

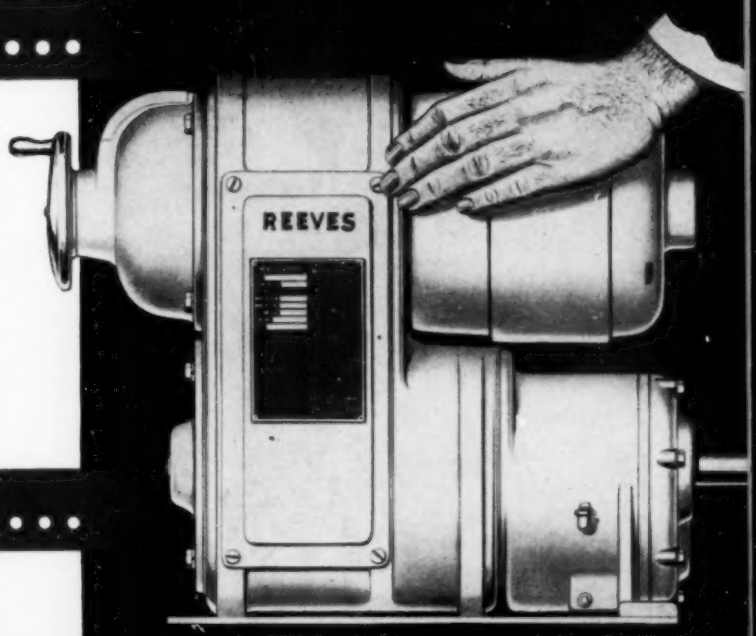
REEVES Variable Speed Drives

Any you

with Motodrives . . .

● Small, compact, but *rugged* REEVES Fractional hp Motodrive gives increased output, greater efficiency and uniform production from your light machinery. In one space-saving unit encased in newly-designed, lightweight housing, REEVES Fractional hp Motodrive brings you: A standard NEMA face-mounted motor and REEVES time-tested speed varying mechanism for positive, accurate, speed changes without stops. Horizontal units are 9⅝" high; vertical units 16⅞" high. Available in ¼, ⅓, ½ and ¾ hp capacity with speed ratios up to 10:1.

For heavier duty, *integral* hp REEVES Vari-Speed Motodrives are available with capacities to 30 hp and with speed ratios from 2:1 through 6:1.



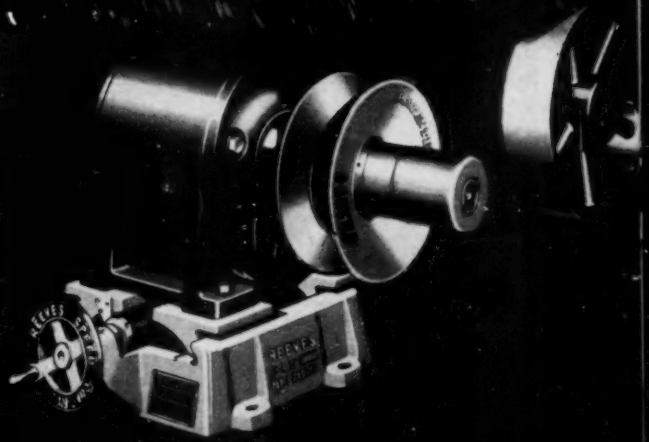
with Flexi-Speed Drive . . .

● For extreme versatility in operation and application, *simplicity* and *economy* in installation and *speed range of 8:1*, choose REEVES *new* Flexi-Speed Drive. Essentially a Motodrive without housing, REEVES Flexi-Speed Drive is a compact combination of constant speed disc assembly with shifting mechanism, mounted on the drive shaft; variable speed pulley mounted on the driven shaft; and double-cog belt linking the two. Converts any standard motor into a highly flexible variable speed drive. Easily adapts for right angle applications. Available in ½, ¾ and 1 hp capacities.

with Motor Pulleys . . .

● Boost your production in light or heavy duty work applications by converting your fixed speed motors to infinitely variable drives with REEVES Vari-Speed Motor Pulleys . . . the simplest, most economical way known to industry.

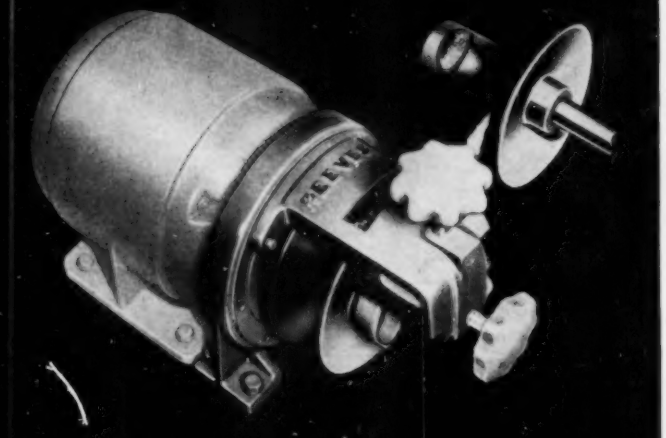
Two styles available—Vari-Speed Junior, for use with Standard A or B section V-belts, carrying loads up to 1½ hp; Standard Line, using REEVES Vari-Speed belt, sizes up to 10 hp. Speed ratios as high as 4:1 inclusive.



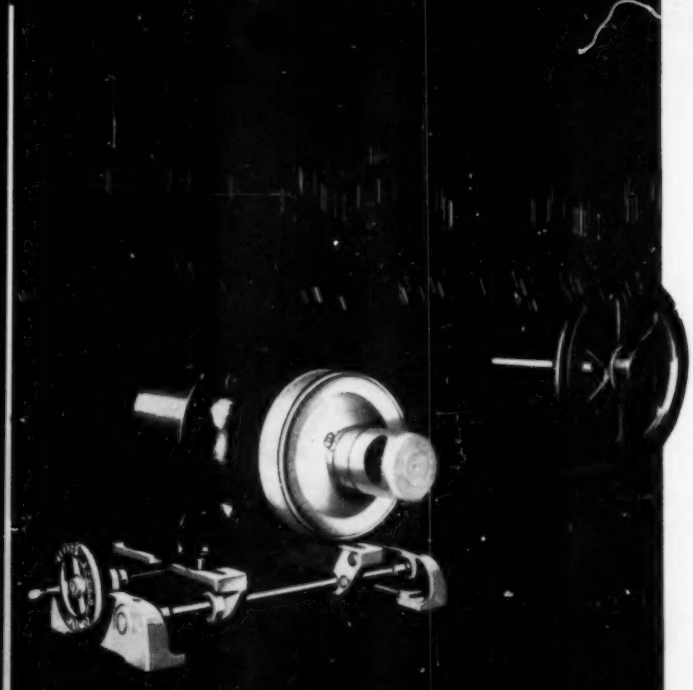
REEVES VARI-SPEED MOTOR PULLEY

speed need

-anywhere you need it! fractional to 87 hp



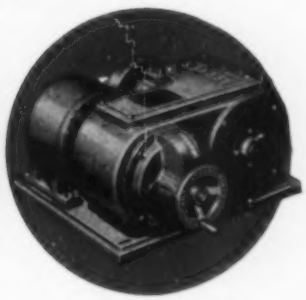
REEVES FLEXI-SPEED DRIVE



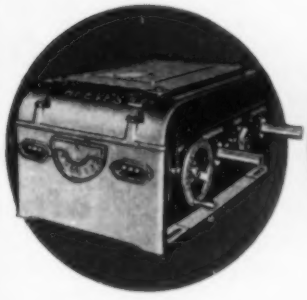
REEVES VARI-SPEED JR.

Other Units in the Complete REEVES Line!

VERTICAL MOTODRIVE



HORIZONTAL MOTODRIVE



VERTICAL TRANSMISSION

HORIZONTAL TRANSMISSION

REEVES offers many different methods of control for changing speeds—either manually or automatically—handwheel, which is standard, electric, or completely automatic.

For machines you buy or build, obtain *all* the benefits of stepless speed adjustability by specifying **REEVES** Drives. Send for catalog, No. K87a-1-3N.

REEVES
SPEED CONTROL

REEVES PULLEY COMPANY • COLUMBUS, INDIANA
Recognized leader in the specialized field of variable speed control

Have you a temperature control problem from -20°F to 550°F?

KLIXON *Thermo-Snap* CONTROLS

can meet your requirements... often reduce costs, too!

What's your temperature control problem... high or low limit, fan control, temperature control... on boilers, clothes dryers, unit and space heaters, refrigeration and electronic equipment... Klixon Thermo-Snap Controls are now meeting the requirements for these and other uses in military and civilian products.

The enormous advantage of the Klixon Control is the simple, fool-proof actuating element... the Spencer snap-acting thermostatic disc which always makes a quick, clean break or a sure, solid make no matter how often it operates. And because the Spencer disc is snap-acting, it is not affected by shock, vibration, motion or high altitude no matter in what position it is mounted. In addition, Klixon Controls are small, compact and light in weight.

Klixon Thermo-Snap Controls, hermetically sealed and open types, are available in many types, shapes and sizes, in a wide variety of operating temperature ranges.

Klixon Engineers, specialists in temperature control applications, can help you solve your specific problems. Write for their help or further information.

KLIXON

SPENCER THERMOSTAT

Division of Metals & Controls Corporation

911 FOREST ST., ATTLEBORO, MASS.

By testing motors under desert conditions G.E. gives you more for your motor dollar

This motor is being removed from the dust chamber at Fort Wayne, Indiana, for inspection by G.E. Engineers. Subjected to many gruelling hours in hot, wind-driven sand, it has endured conditions tougher than any it will be expected to meet in service.

Used to detect the particular problems of desert operation, the dust chamber typifies the engineering thoroughness and precision at General Electric—the resourcefulness that helps build better quality fractional-horsepower motors—of all kinds—for you. Whatever your motor problem, remember that G.E. Engineers have both the testing facilities and skill to solve it. And if there is not a motor in the G-E fhp line to exactly solve your own special problem, chances are G.E. can design and build the motor that will.

For more information or engineering assistance, contact your nearby G-E Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y.

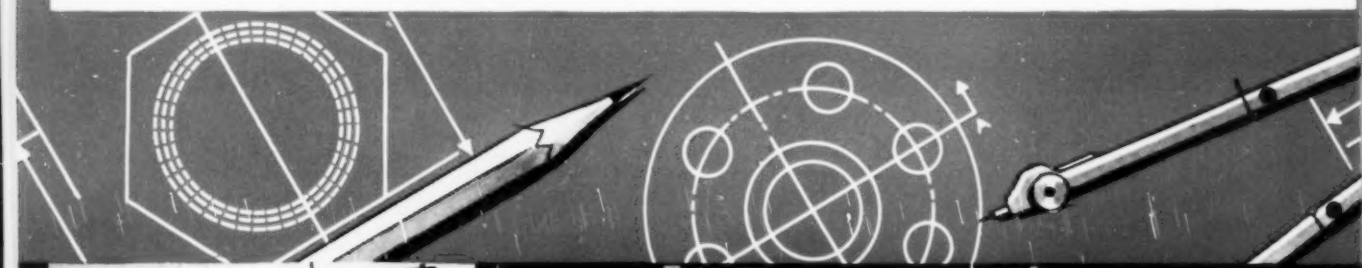
You can put your confidence in—

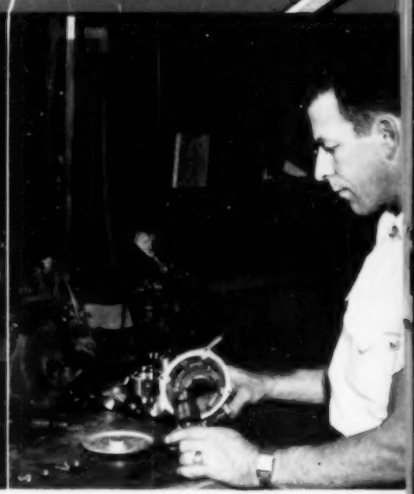
GENERAL ELECTRIC

Need engineering help?

SCOTT AND FETZER PRESENTS PROBLEM to G-E Engineer: how to get a more powerful, yet cooler-operating motor for the Scott and Fetzer Kirby Home Sanitation Sy-tem in same frame size.

G-E ENGINEERS REDESIGNED the motor windings, and eliminated the tape from the field. This solution was worked out by the G-E Specialty Motor Department in Fort Wayne.

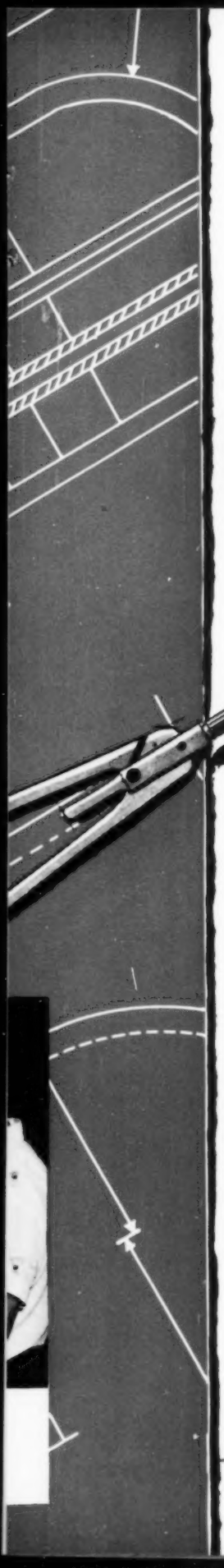




12% MORE POWER was achieved by the Specialty Motor Department's design, yet the temperature rise was cut by almost 50%.

SAME SIZE, SAME COST to customer meant no costly redesign of their product, or extra cost for its better motorization.

INTERCHANGEABLE PARTS, in new motor, eliminate any service problem with older units now in the field.



Here's proof that

It pays to get motor application help from G.E.

Designing skill unbeaten anywhere is behind the significant Scott and Fetzer story told briefly on the left. It typifies the practical advantages you gain when you take advantage of General Electric's motor application service.

Scott and Fetzer, to get the power they needed, were faced with redesigning their product to accommodate a larger, more powerful motor. They took their motor application problem to G.E. The Specialty Motor Department at Fort Wayne gave them the power they needed in a motor of exactly the same size which didn't cost them a cent more!

G.E.'s engineering experience, skill, and thoroughness, which helped Scott and Fetzer, is ready to help you. G.E. Engineers, backed by years of experience in solving motor problems of every kind, will work with you to design the motor which exactly fits your special needs.

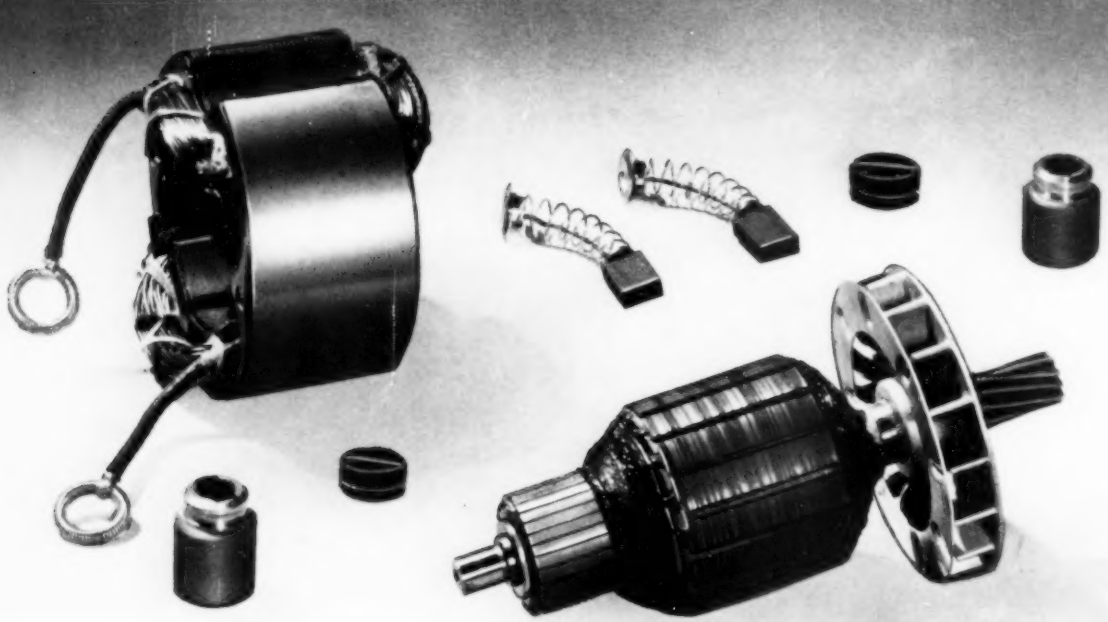
Next time you have a motor designing problem, take it to your nearby General Electric Apparatus Sales office. General Electric Company, Schenectady 5, N. Y.

You can put your confidence in—

GENERAL ELECTRIC

need series motor parts?

MADE TO MATCH YOUR HIGHEST STANDARDS



Use G-E series motor parts for rugged, reliable tools

Designed for heavy-duty service where momentary overload and no-load operation is experienced, General Electric heavy-duty series motor parts are completely reliable in the most rugged applications. These and the normal service parts are designed to precisely fit your particular requirements.

ENGINEERING KNOW-HOW. To improve your current model, or to be sure of the finest design possible for a new one, it will pay you to take your design problems to a G-E Motor Application Engineer. His experience can help you make profitable reductions in size, weight, and cost, as well as improve tool performance . . . appearance . . . and service life.

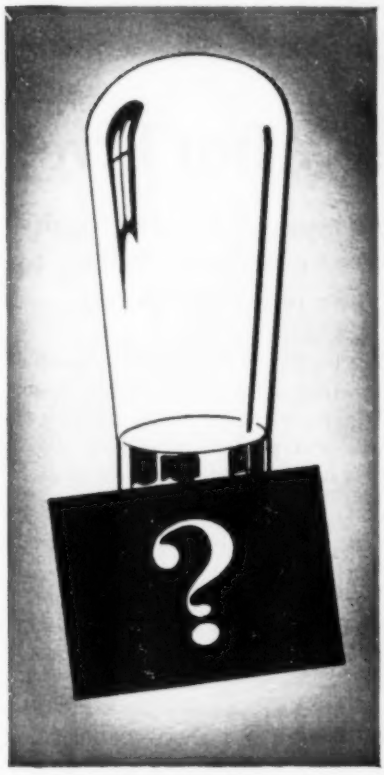
GEAR DESIGNING. Because gearing is often an integral part of a motor application problem, G.E. maintains a gear design group staffed by experts in the field of fine-pitched gearing. They co-ordinate their work with the motor application engineers to give you the best combination possible of motors and mechanical parts—the best portable tool you can build.

The quality and dependability of G-E Series Motor Parts, and the experience of G-E Application Engineers can combine to solve your design problems. Find out about them. See your nearest General Electric Apparatus Sales Office, or write for Booklet GEA-5665, Sec. 704-9, General Electric Co., Schenectady 5, N. Y.

You can put your confidence in—

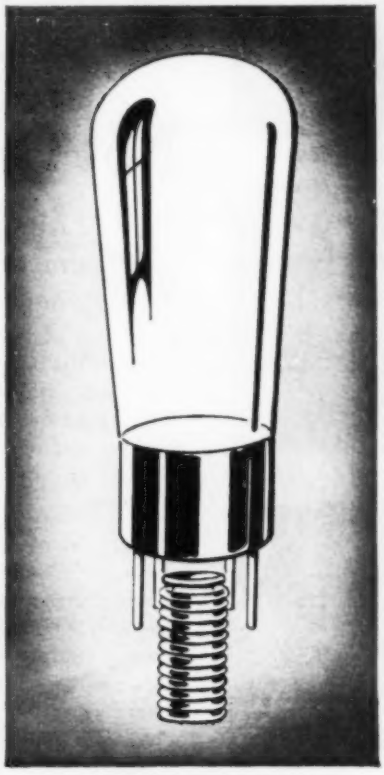
GENERAL ELECTRIC

IDEAS that started in a BELLOWS



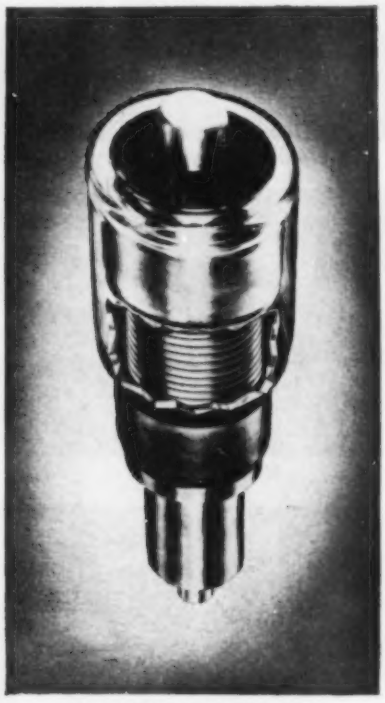
ONCE THOUGHT IMPOSSIBLE

How to reach into a high vacuum tube without breaking the seal — once stumped many an engineer.



NOW "STANDARD PROCEDURE"

Today Clifford supplies a whole line of bellows to make a wide range of adjustments and settings inside a vacuum.



AND HERE'S THE ANSWER

Moving variable plate inside vacuum capacitor was the problem solved through the use of Clifford Hydron bellows assemblies by Jennings Radio Manufacturing Company. Being leak-proof and flexible, Clifford Hydron bellows form a perfect seal for the vacuum while permitting full movement of the variable plate.

Have you ever worked with Bellows?

"Bellows" haven't been in the engineering courses — but they have helped to solve some of today's knottiest engineering puzzles.

Clifford Hydron Bellows make flexible hermetic seals, permit extension, retraction and 360° rotation with 100% metallic seal.

In the electronic field Clifford Hydron Bellows are used for changing frequency inside magnetron tubes, making adjustments inside hermetically-sealed instruments, moving variable plates inside vacuum capacitors. They are also being used as expansion chambers in mercury-filled wave guides, oil filled transformers and other electronic and elecrical equipment.

Clifford Bellows come in monel, stainless steel and other metals having very low gas transmission and emission properties. They are assembled to meet individual requirements. Coupon will bring you additional information.

CLIFFORD MANUFACTURING COMPANY, 122 Grove Street, Waltham 54, Massachusetts. *Division of Standard-Thomson Corporation.* Sales offices in New York; Detroit; Chicago; Los Angeles; Waltham, Massachusetts.

CLIFFORD MANUFACTURING COMPANY
122 Grove Street, Waltham 54, Massachusetts

Gentlemen:

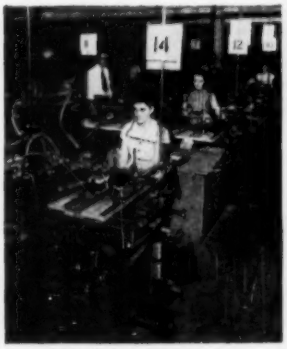
Please send me information on bellows application for vacuum tube adjustments. Also for:
☐ Transmitting motion between two mediums ☐ Controlling and indicating temperature ☐ Sealing rotary shafts or packless valves ☐ Transmitting motion hydraulically to remote points ☐ Providing for thermal expansion ☐ Providing shock mounting or vibration dampening ☐ Differential pressure maintenance

Name.....

Company Name.....

No. and Street.....

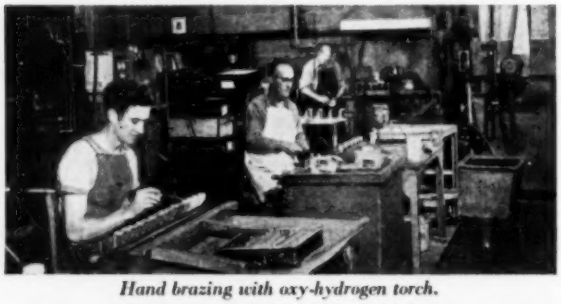
City.....*Zone*.....*State*.....



Gas brazing equipment.

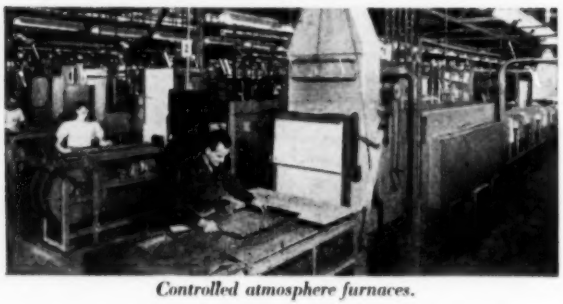
Induction brazing unit.

STOP
YOUR CONTACT TROUBLES
BEFORE THEY START



Hand brazing with oxy-hydrogen torch.

Resistance brazing machines.



Controlled atmosphere furnaces.

Not One...But Five!

All five types of brazing equipment are available at Mallory to meet your particular needs.

On even the simplest button or rivet contact, trouble can start with the wrong method of bonding. Size, shape, nature of the material, frequency and degree of impact, tooling costs and production quantities . . . all must be considered in selecting the one best method of brazing.

Mallory is equipped to make completely unbiased decisions in selecting the best and most economical brazing technique for any type of contact or contact assembly. Our plant is equipped with all five types of brazing equipment . . . as well as four types of resistance welding equipment. Facilities are available in the laboratory as well as on the production floor. Production techniques are worked out ahead of time . . . before production runs are started . . . so you can be sure of completely dependable contacts, economically produced.

This is only part of the story, however. If you want the rest of it, our engineers will be glad to send you complete information . . . or answer any questions you may have regarding the design and production of the contacts for your products.

Expect more...
Get more from **MALLORY**

In Canada, made and sold by Johnson Matthey and Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

Electrical Contacts and Contact Assemblies

P.R. MALLORY & CO. Inc.
MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:
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Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

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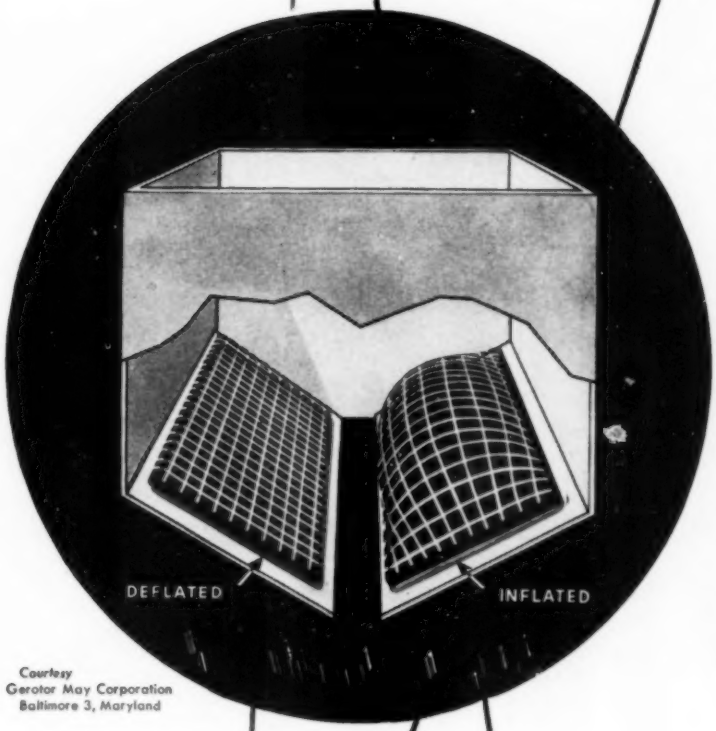
FLEXIBILITY

ABRASION RESISTANCE

CHEMICAL RESISTANCE

These properties of neoprene make a better STORAGE BIN



Courtesy
Gerotor May Corporation
Baltimore 3, Maryland

Inflatable panels mounted on the inner walls of storage bins offer a new way to eliminate "hang-ups" due to jamming of the contents. Each panel is composed of an elastic neoprene diaphragm covering a steel plate and bonded to it on the back. Fed by compressed air, the diaphragms balloon out and then release . . . break up jams and keep materials moving.

This new-type "inducer" works equally well on fluffy wood flour, chemical salts that form a solid cake in a bin, and even heavy viscous mud. A control device governs the amplitude and frequency of inflation, permitting adjustment for best results. Other advantages include quiet operation, better mixing action, and freedom from the contamination and damage often caused by mechanical agitators.

These inflatable panels owe much of their versatility to neoprene's remarkable properties. For neoprene combines the required flexibility with the toughness to withstand severe abrasion. And because of its resistance to flex cracking and to attack from oil and chemicals, the panels remain free from weak spots or leaks. It's another example of the exceptional opportunities in design offered by Du Pont neoprene.

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:

Air and Gas Diffusion	Permanent Distortion	Abrasion, Cutting, Chipping	Oils, Solvents, most Chemicals
Low Temperature Stiffening	Sunlight and Weathering	Oxidation	Heat

DU PONT

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NEOPRENE

The rubber made by Du Pont since 1932

FREE! **THE NEOPRENE NOTEBOOK**

Each issue shows new, unusual applications of neoprene . . . new products . . . improved designs. The neoprene application cited above is covered in detail in Notebook No. 53. Add your name to the mailing list today.

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division PE-11, Wilmington 98, Del.

Name_____ Position _____

Firm_____

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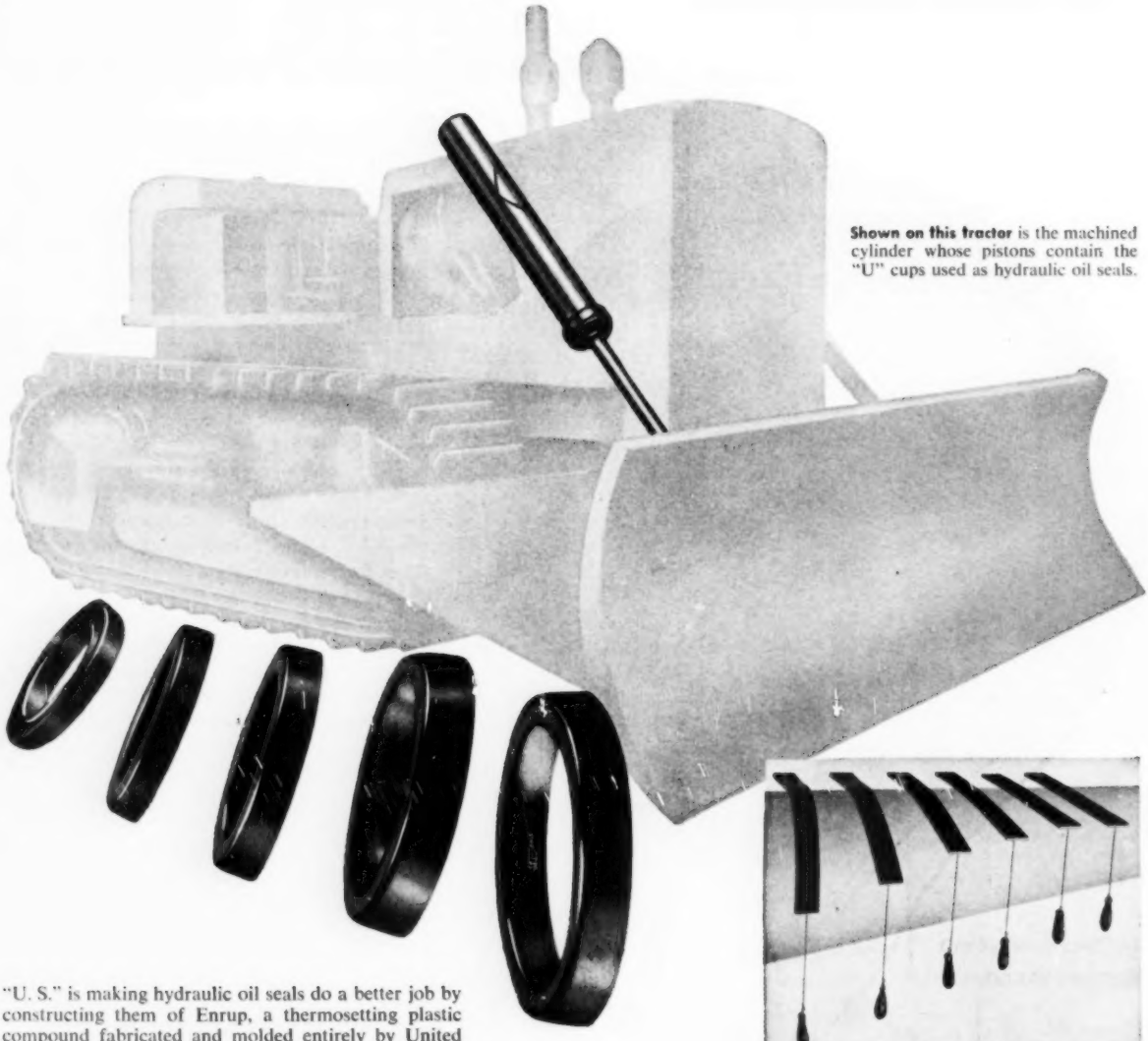
City_____ State_____

What's U. S. Rubber doing with hydraulic oil seals?



Shown on this tractor is the machined cylinder whose pistons contain the "U" cups used as hydraulic oil seals.

"U. S." is making hydraulic oil seals do a better job by constructing them of Enrup, a thermosetting plastic compound fabricated and molded entirely by United States Rubber Company engineers. Five sizes of this seal are being used on machined cylinders on tractors and other heavy road-building equipment. These seals last much, much longer than the seals previously used.

Enrup has unusual abrasive resistance, can be molded to close tolerances, and can be machined. It has high impact strength and great toughness. You may find that Enrup is just what you have been seeking to improve your product. Consult any of the 25 "U. S." District Sales Offices, staffed with engineers to serve you, or write to address below.

These are the "U" cups made of Enrup, used as a hydraulic oil seal on tractors and other heavy road-building equipment.

Between the extreme elasticity of soft rubber (the strip at the extreme left) and the rigidity of hard rubber (strip at extreme right) are 4 strips of Enrup. Note varying degrees of flexibility, making Enrup a true bridge between hard and soft rubber.

U.S. RUBBER
SERVING THROUGH SCIENCE

"U.S." Research perfects it
"U.S." Production builds it
U.S. Industry depends on it

UNITED STATES RUBBER COMPANY

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NOVEMBER 24

NOVEMBER 25

Order 52100 tubing today...

We'll ship tomorrow

NEED 52100 tubing on the double for a rush hollow parts job? Phone or wire today and we'll ship within 24 hours. One hundred and one sizes of Timken® 52100 steel tubing—from 1″ to 10½″ O.D. —available for less-than-mill-quantity orders.

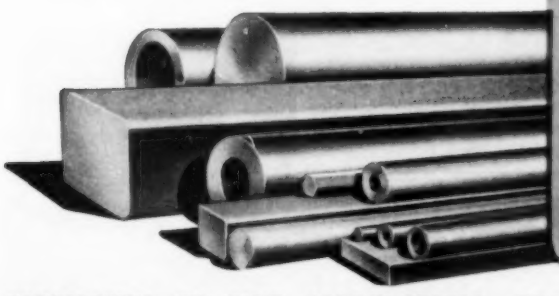
Timken 52100 steel will do most of your hollow parts jobs, often can be used in place of more expensive steels. It's a high-carbon chrome steel and is through hardening in moderate sections. Can be heat treated to file hardness and tempered back to any desired point.

52100 is ideal for hollow parts jobs such as aircraft parts, ball bearing races, pump parts and plungers, collets, bushings, spindles, grinding machine parts and precision instrument parts.

As America's pioneer producer of 52100 tubing, the Timken Company has a backlog of experience that can't be topped. Result: you get uniform high quality from tube to tube and order to order.

For immediate delivery of your less-than-mill-quantity orders, write, or phone The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



TIMKEN
Fine Alloy
STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

MAXITORQ

Overload Release CLUTCH

minimizes machine Down-Time

AT THE
GILLETTE SAFETY RAZOR CO.

The Maxitorq automatic Overload Release Clutch was designed especially to protect high-speed machinery, and we are gratified to have testimonials such as the following:

> "The Gillette Safety Razor Company chose the Maxitorq Overload Release Clutch to protect a section of their blade and shaving cream packaging machines against costly down-time due to unpredictable machine jams.
>
> "Over a period of a year, wrapping millions of blades per week, Maxitorq Clutches have eliminated machine down-time except in a few minor instances. Thus, more constant production has been maintained in the packaging department."

When an accidental overload occurs, the clutch automatically releases, stopping the machine, preventing damage to machine and product. When the jammed condition has been cleared, the clutch is re-engaged and the machine is again in operation. By means of a simple finger-tip adjustment, the clutch is set to transmit the normal running load.

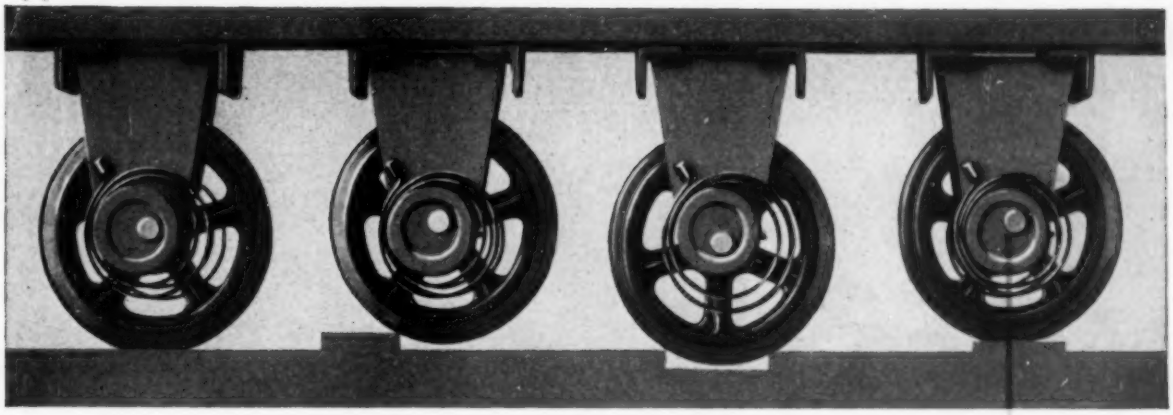
There are six sizes, ¼ to 5 h.p. @ 100 r.p.m.; max. working torque ft. lbs. 13 to 263. Maxitorq "floating" discs prevent heating in neutral, and all assembly, take-apart, and adjustments are manual; disengagement is instant and complete. Submit your clutch problems to our engineers for practical solutions.

SEND FOR CATALOG NO. PE-11.

8CJ53

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

GRAMIX® BEARINGS in new swinging hub casters help shop trucks roll smoothly over rough, bumpy floors



The new swinging hub caster is designed and built by Standard Manufacturing Company of Mt. Airy, North Carolina, for shop trucks, dollies, trailers and other materials handling equipment. Operating on a clever adaptation of a spring-centering principle, the new caster "steps" over bumps, protecting the cargo it carries from shocks and jolts and providing a smooth, virtually noiseless ride over rough, uneven floors. GRAMIX bearings at the hub of each caster help account for this remarkable performance. These bearings have a porous structure and can be oil-impregnated during manufacture to provide a constant film of oil at the bearing surface, insuring smooth, quiet operation and helping to absorb vibration. Designed for a rated load of 800 lbs. per wheel, the casters consistently carry loads up to 2000 lbs. per wheel with ease. GRAMIX bearings, gears and other parts are compacted from powdered metals under pressures up to 70,000 lbs. and sintered in high temperature furnaces. They can be produced in relatively complicated shapes to tolerances as close as .0005". They need little or no machining thus virtually eliminating scrap loss and waste. GRAMIX parts are strong and tough and will usually outperform and outlast similar machined parts for only a fraction of the cost in production quantities. They can increase the efficiency of your products and perhaps reduce your costs considerably.

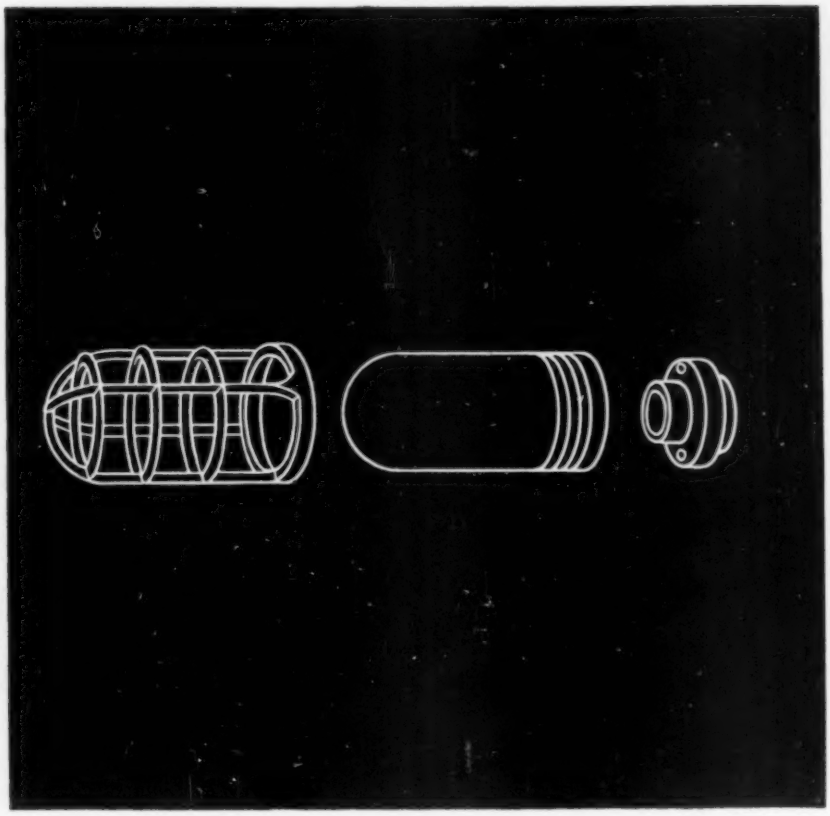
98

GRAMIX CATALOG FREE

The new illustrated GRAMIX catalog is full of facts and figures, charts and data that tell you all about GRAMIX parts. Chances are it will suggest many ways in which GRAMIX parts can improve your operations. Write us today for your free copy.

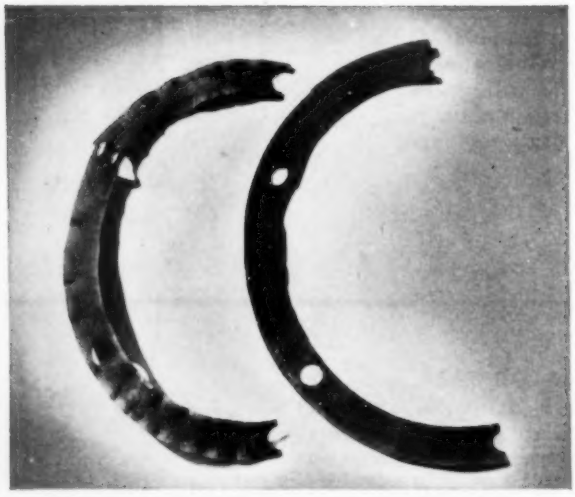
THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN



NEW FIBER GASKET

...seals vapor out of lamp,



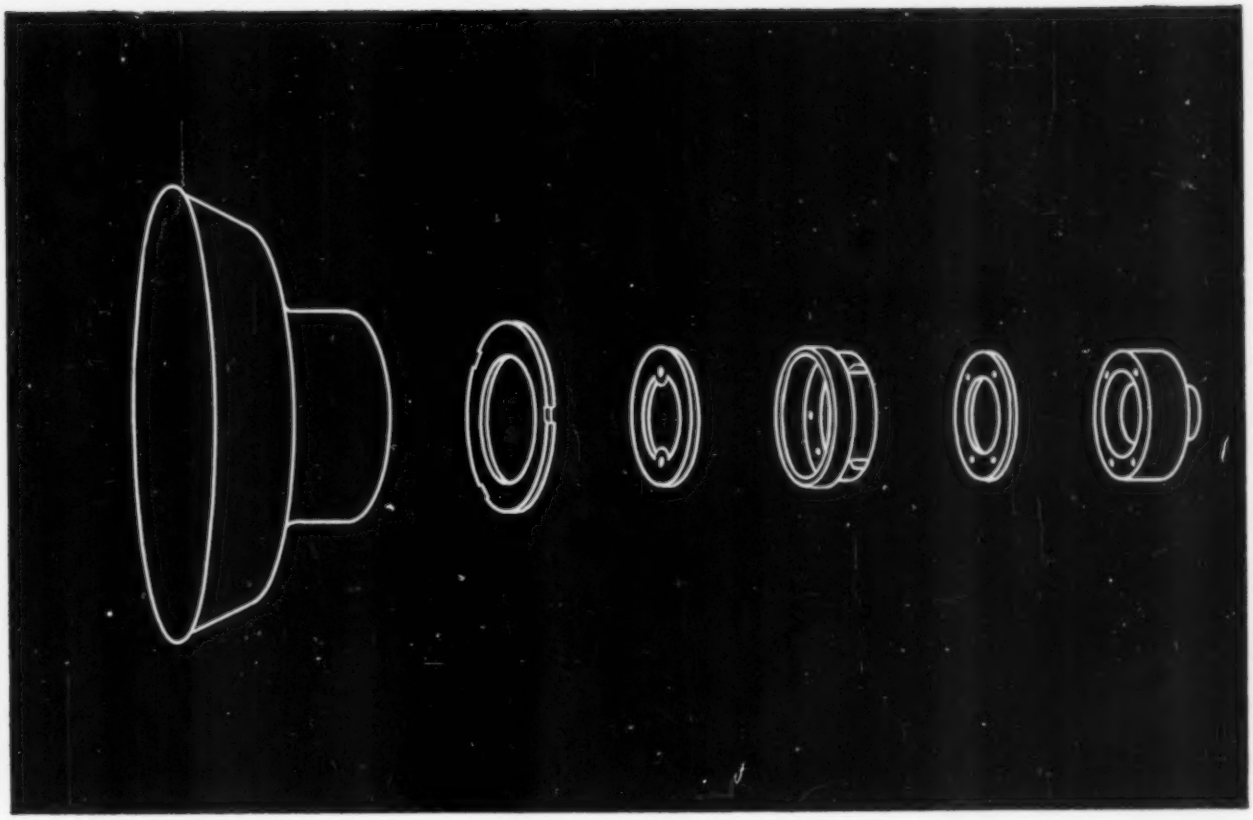
NEVER SHRINKS OR DRIES OUT. Both these gaskets were used for six months in a gear pump circulating hot hydraulic oil. The plant fiber gasket (left) lost its glycerine plasticizer, dried out, shrank, became hard, brittle. The Accopac gasket (right) remained virtually unaffected, as the photograph clearly shows.

Investigation of field complaints showed a lamp manufacturer he had an unusual gasket problem. His gaskets, which were doing a good job of keeping water vapor out, were nonetheless causing considerable dimming. The 350° F. heat of the lamp vaporized the binder in the gaskets. The extracted binder formed a dark deposit at the base of the lamp cover.

To correct this, he tried an entirely new kind of fiber gasket material—Armstrong's Accopac®. Severe testing proved that Accopac filled both his basic requirements—it made a vapor-tight joint under the low pressure of hand-tightened nuts, and its binder stayed in the gasket.

Won't shrink or dry out. Accopac contains only one binder—non-extractable latex. Unlike most fiber materials, Accopac is not made by dip-saturation, but by a patented variation of the beater saturation process. For this reason, Accopac gaskets won't lose their

ARMSTRONG'S



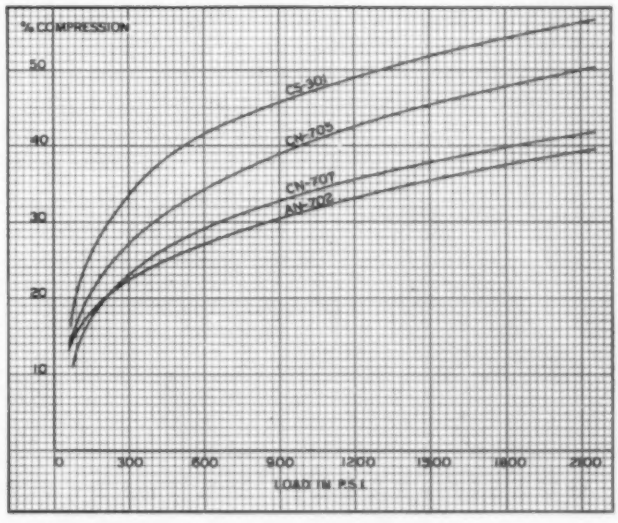
solves serious dimming problem

binder to heat or solvents. They also have nearly-perfect dimensional stability over long periods of storage.

Cork particles add compressibility. As you can see from figure 2, Accopac has a compressibility unusual in fiber materials. Thousands of tiny cork particles are blended with the fiber and latex to assure you of a tight seal under low pressure.

FREE GASKET MANUAL

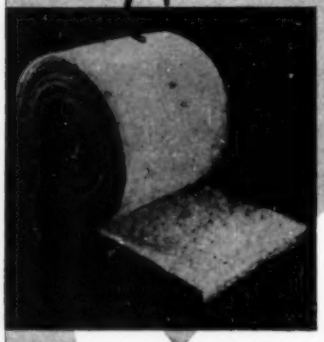
For full information on Accopac and other versatile gasket materials, write for the 24-page manual, "Armstrong's Gasket Materials." In addition to full product data, it contains the latest Government and SAE-ASTM specifications, plus helpful design information, including sections on cost reduction, gasket tolerances, flange design, etc. Write Armstrong Cork Company, Industrial Division, 7011 Irvin Street, Lancaster, Pennsylvania.



HIGH COMPRESSIBILITY of Accopac is shown by these load-compression curves. With light or stamped metal flanges, this compressibility allows gaskets to conform to irregularities and seal without distorting the flange. On heavy flanges, Accopac gaskets seal without crushing.

ACCOPAC

frankly, we're fishing...

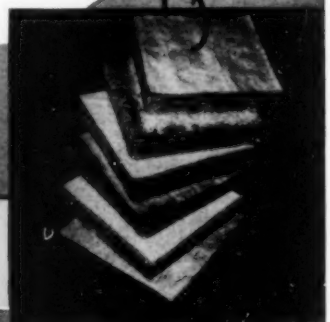


... Because we have a unique glass fiber product with an amazing combination of properties that may well be just what you're seeking.

The product is ULTRALITE, the only insulation of l-o-n-g glass fibers. It won't rot, burn, absorb moisture, or support insect life. It won't chip, dent, flake, break or deteriorate with age. Most important of all, ULTRALITE is r-e-s-i-l-i-e-n-t. You can compress it, shake it, bend it, bump it—yet ULTRALITE springs back into original shape and thickness, and *retains its original thermal and acoustical values.*

This unique insulating material — available in rolls or in ready-to-use die-cut pieces, with or without facings adhered — has been enthusiastically received by design and development people and production superintendents. It is saving time and money, as well as improving product efficiency, in trucks and trailers, railroad cars, house trailers, furnaces, air conditioners, household appliances, portable coolers, automobiles, and other insulated O.E.M. equipment.

If the control of heat, cold or sound is important in the manufacture or delivery of your product, it can pay you well to get the facts on this superior thermal and acoustical insulation. To find out what ULTRALITE will do for you, write today for samples, applied cost comparisons, and complete performance data.



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Keeping pace with the Nation's industrial requirements through research and development—our 54th year.

Illustration shows a new aluminum slitting line in the Birmingham, Ala., plant of Southern States Iron Roofing Company.

WORM GEARING—universal in its application—affords advantages for almost every power transmission job. Select worm gear drives to meet your needs from the Cleveland line.

Aluminum slitting line has CLEVELAND worm gear drive

TO keep this aluminum slitting machine working without interruption is the job of its Cleveland worm gear drive. Recently installed in a southern distributor's warehouse, the unit is turning out a steadily increasing volume of aluminum coiled sheet, slit to special widths for customers' convenience.

North or South, machine builders and users specify Cleveland whenever they want a powerful, compact, right-angle drive. Every Cleveland is built to work under toughest conditions without a hitch. Case-hardened steel worm meshes with nickel-bronze gear for long years of service without appreciable wear. There is a minimum number of moving parts to cause trouble.

For the latest information on how Cleveland can solve your power transmission problems, write for Catalog 400. The Cleveland Worm & Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

2 EXCLUSIVE FEATURES
OF ROCHESTER PRODUCTS
WELDED STEEL GM tubing

LESS "SHORT END" WASTE
FEWER JOINTS—
LESS CHANCE OF LEAKAGE
LOWER PRODUCTION COSTS

Only GM Welded Steel Tubing is available in 1500-2000 foot random coils . . . as well as in straight lengths, or formed to your specifications. Sizes from ⅛" to ⅝" O.D., in a choice of plain, Terne coated, copper plate, or exclusive GM copper Fuse-Kote finish.

Mass-produced by Rochester Products at the rate of *hundreds of thousands of feet daily*, GM Steel Tubing lends itself to all types of fabricating operations. We believe it will pay you to consider its many time-and-money-saving features!

COPPER PLATING

In GM Steel Tubing, Rochester Products offers you the *only* steel tubing available with *COPPER PLATING*. Without adding copper, you can braze the tube to other parts such as fins or plates. One user reports material savings of 1200%!

- **BRAZE without adding copper**
- **SAVE time and material**

SEND FOR *Free* BROCHURE

Entitled *"Better Products for Greater Progress...,"* this new, illustrated, fact-packed brochure tells how GM Steel Tubing can help solve design and production problems. Send for your free copy today.

RP STEEL TUBING

ROCHESTER PRODUCTS, *DIVISION OF GENERAL MOTORS,* **Rochester, N. Y., U. S. A.**

Better Products Thru Better Design

how MICRO switches and MICRO field engineering service can help you meet competition...

RARELY in recent years has the demand upon designers for better products been more pressing. Indications multiply that the long-expected "buyer's market" is now with us.

For the first time in many years it is not enough to have a product to sell. "How soon can I get delivery?" has been replaced with such inquiries as "Just what will it do?," "How long will it last?" and the all-important "How much does it cost?"

As manufacturers and their design and sales staffs prepare for this new competitive market, the pressure is on design and development engineers to re-evaluate every part, every component and every product to improve its performance, increase its life and, perhaps, to reduce its cost.

If your organization is seeking ways to improve its position in the competitive field, MICRO has a message for you. This is particularly true if a more efficiently designed product is indicated. Or, perhaps, you wish it to do things that other similar products won't do.

Nothing so stamps a product as being of high quality as absolute reliability. To the manufacturer it means the enhancement of his good name. To the dealer it means freedom from maintenance and costly warranty replacements. To the customer it means long and satisfactory performance.

To this search for increased reliability MICRO brings a small, precision switch for those designs where less accurate switches won't do. This is because MICRO switches are so well and precisely built and have such uniform quality of operation that, once installed, their accurate performance is so routine that their presence is almost forgotten.

A switch to control the thermostat in a refrigerator or an air conditioning unit, for instance, must always operate within exceedingly close differential control. Even a slight drift cannot be tolerated.

A switch in a household appliance, which turns on the water to operate a motor, must turn on the water at exactly the same water pressure each time. Too little water pressure and the motor starts too soon . . . too much and water splashes over.

A switch in a business machine is required to stop the machine if even the thickness of an extra sheet of tissue paper passes beneath the switch actuator.

These are some of the contributions MICRO switches have made to absolute reliability in the design of better products. MICRO field engineering is available to assist you in the selection of the switch that will enable your product to do things other products won't do.

MICRO

MAKERS OF PRECISION SWITCHES

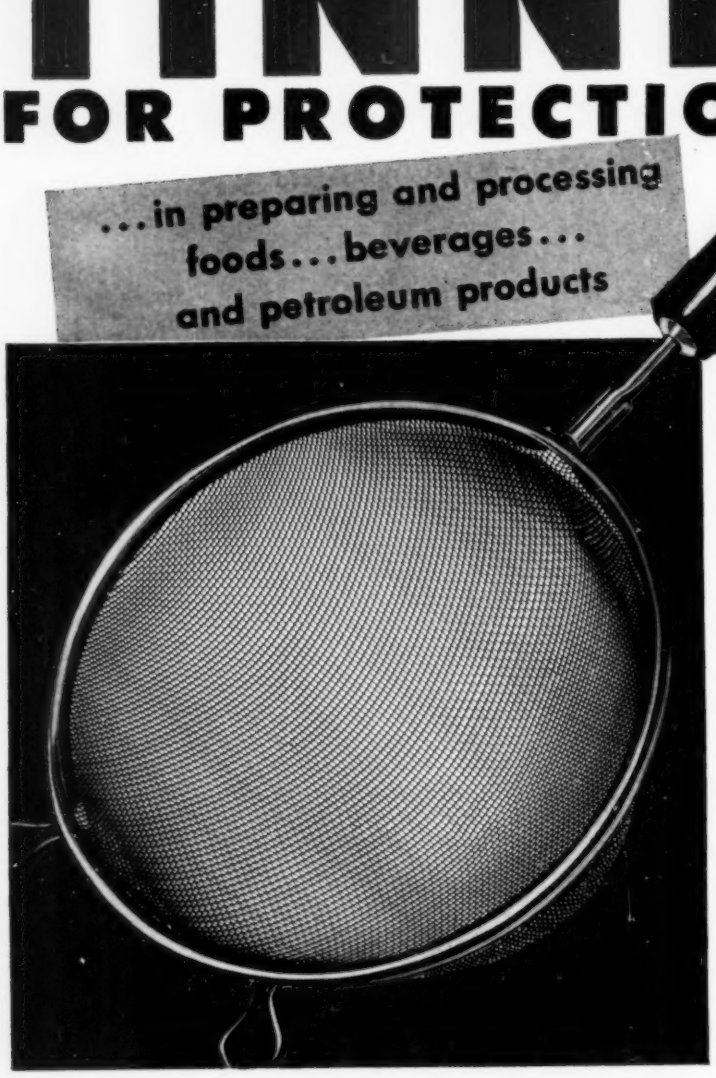
FREEPORT, ILLINOIS

A DIVISION OF

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

TINNED--
FOR PROTECTION

...in preparing and processing foods...beverages... and petroleum products



Why are kitchen strainers, tea strainers, flour sifters, french fryers, automatic dish washer baskets and many other kitchen tools made of Reynolds *tinned* wire cloth?

Because tinning means resistance to rust and tarnish resulting from contact with milk, water and atmospheric gases.

Tinned wire cloth is also resistant to phosphoric acid, ammonia, carbon tetrachloride, etc.; and substances present in motor fuels and other petroleum products.

And, wherever high speed soldering is a factor—as in electrical products—Reynolds tinned wire cloth is a natural.

Whether your products are used in the kitchen, dairy, food processing and preservation, or the beverage, petroleum, or electrical industries—you'll be interested in Reynolds Wire Cloth. And, tinning is only *one* of the many special-needs demands that *Reynolds* Wire Cloth is or can be made to meet. Consult Reynolds engineers. No obligation.

Reynolds WIRE CLOTH
protects performance

REYNOLDS WIRE DIVISION, NATIONAL-STANDARD CO., **DIXON, ILLINOIS**

Divisions of National-Standard Co.

ATHENIA STEEL...*Clifton, N. J.*.....Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD...*Niles, Mich.*.....Tire Wire, Fabricated Braids and Tape
WAGNER LITHO MACHINERY...*Jersey City, N. J.*.....Metal Decorating Equipment
WORCESTER WIRE WORKS...*Worcester, Mass.*....Round and Shaped Steel Wire, Small Sizes

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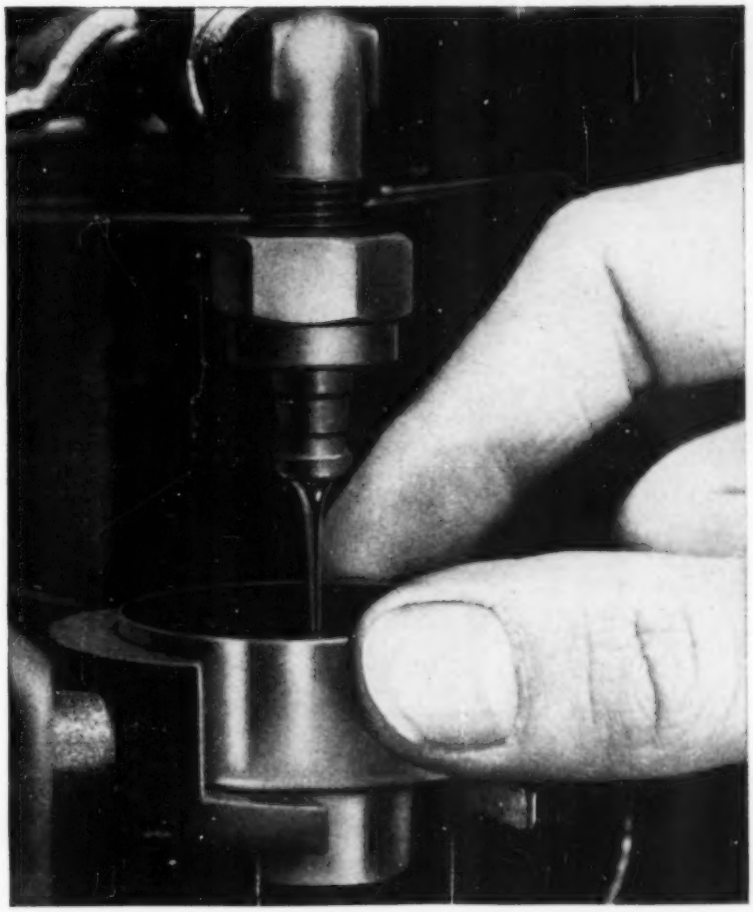
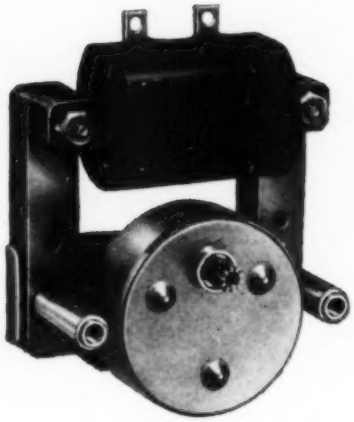
FILLING STATION

...FOR LONG-LIFE LUBRICATION



Telechron Synchronous Timing Motors



MODEL H-10. *Low-cost, light-duty motor capable of handling high momentary peak loads. Ideal for washing machines, dishwashers, refrigerators, and other appliance timer uses.*

Seal the oil in with the moving parts, and they'll both last longer. That's the simple reason behind the long, dependable life of Telechron Synchronous Timing Motors.

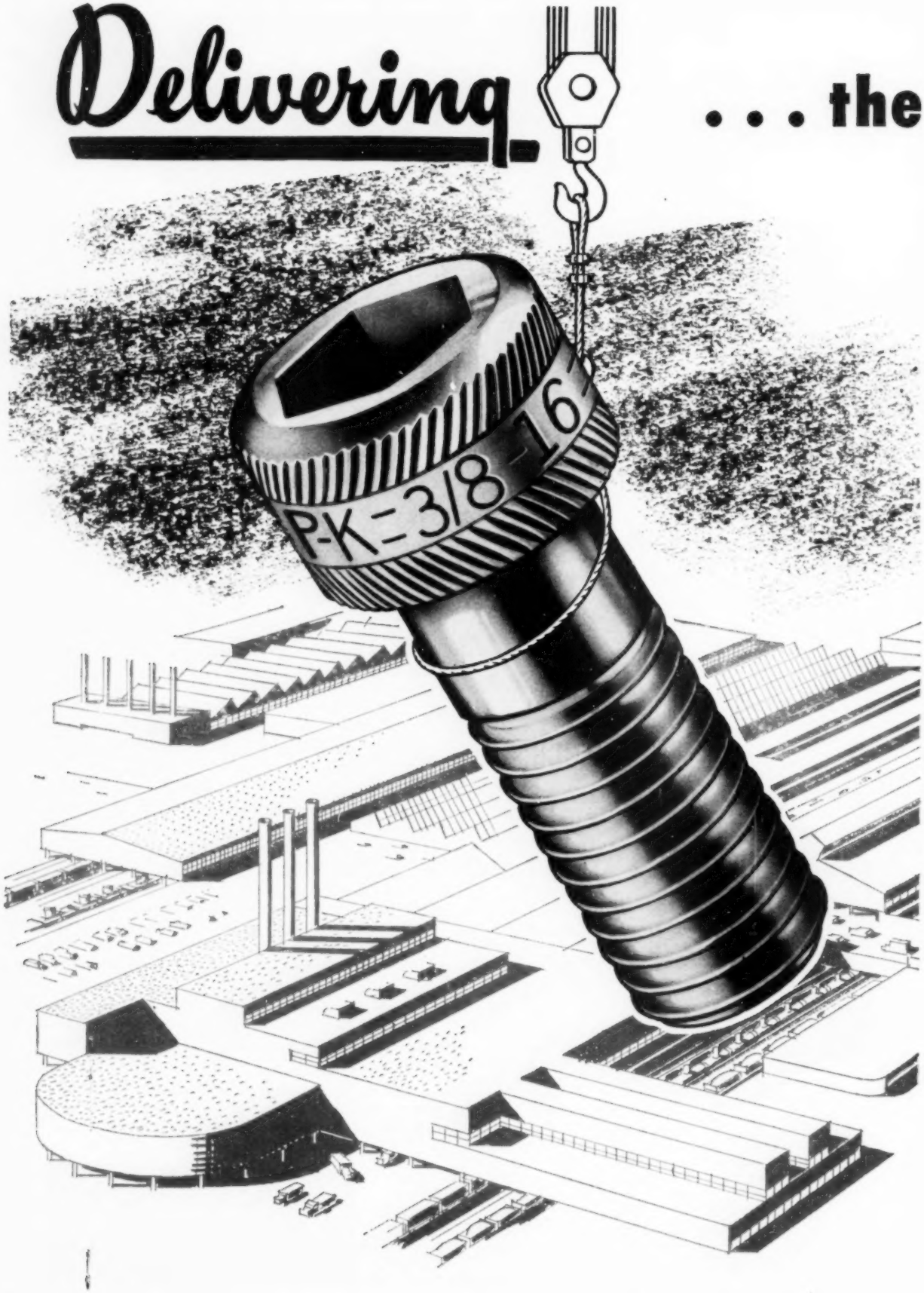
Into each motor goes a measured amount of special oil—carefully formulated for the particular service the motor is to perform. Then the unit is sealed. Dirt and dust can't get in. Lubricant is lifted by capillary action from the reservoir to all bearings, and flows continuously to all gears, efficiently . . . so efficiently, in fact, that many Telechron motors are still operating accurately and dependably after 20 years of continuous use.

There are other advantages, too, in Telechron Synchronous Timing Motors. Quick starting, due to the lightweight rotor. Power-line accuracy, because of true synchronous operation. Cool running, with the field coil isolated from the rotor unit. Altogether, a combination of worth-while features unique in the field of electric timing.

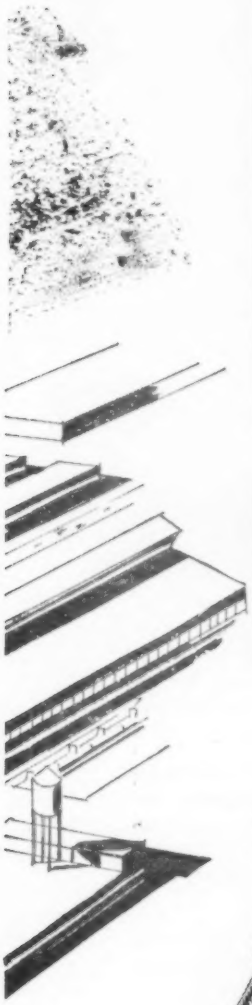
Telechron motors are available in a wide range of speeds and torque ratings, and for any standard AC power source. Get full details. Write Telechron Department, General Electric Co., 111 Homer Ave., Ashland, Mass.

Telechron
MARK OF TIMING LEADERSHIP

Delivering . . . the



fastener ideas of the future



Back in 1942, the Size-Mark on Socket Cap Screws was considered a visionary idea, attainable only in the distant future, by most fastener authorities. Ground Threads on Socket Set Screws were thought another of such "dream" developments.

But Parker-Kalon licked the problems, *delivered* both improvements *within the year,* on P-K Socket Screws.

Originator of so many of the fasteners essential to modern assembly methods, Parker-Kalon has always preserved the pioneering spirit. You can continue to look to P-K for the fastener ideas of the future, *delivered today.*

Get samples of P-K Socket Screws . . . and compare. See why they'll put your product a step ahead . . . assembly-wise and sales-wise.

PARKER-KALON®
SOCKET SCREWS

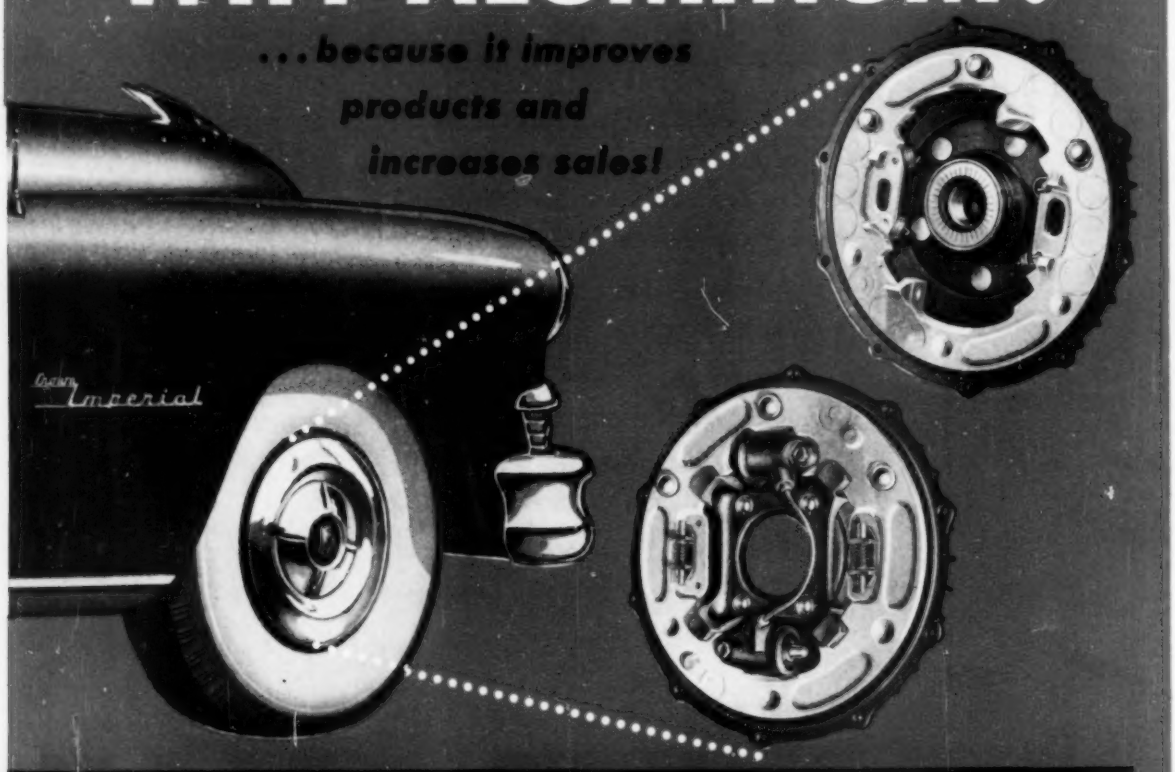
The *only* Size-marked Socket Cap Screws
The *first* Ground Thread Socket Set Screws

SOCKET SCREW DIMENSION FINDER
Helps you plan assemblies. Pocket size plastic slide chart gives essential dimensions of all types of P-K Socket Screws. For a free Dimension Finder, Socket Screw samples, or other data, see your P-K Distributor. Or write: Parker-Kalon Corporation, 200 Varick Street, New York 14.

The INDUSTRIAL DISTRIBUTOR steers your supply dollars to the best values.

WHY ALUMINUM?

...because it improves products and increases sales!



CASE HISTORY: Chrysler Self-Energizing Disc Brake*

Two, lightweight, cast aluminum pressure plates are used in the advanced design Chrysler Disc Brake to quickly dissipate heat generated in braking. This is one example of how aluminum's superior heat transfer can be used to advantage . . . in this case to improve braking efficiency and to prolong brake life.

Other advantages that are proving equally beneficial to manufacturers and operators of cars and trucks include aluminum's low cost, light weight with strength, ease of fabrication, electrical conductivity and corrosion resistance. These factors have influenced the widespread use of aluminum for pistons, transmission and torque converter parts, carburetor bodies, generator and starter parts, battery trays, window frames, trim and a host of other parts and accessories. For more information send for the free folder, "Here's What The Automotive Industry Is Doing With Aluminum."

In almost every industry a change to aluminum has provided manufacturing economies, improved designs and, at the same time, increased sales appeal. Ask Reynolds Aluminum Specialists to help you apply aluminum's advantages to your products and production.

Call the nearby Reynolds office listed under "Aluminum" in your classified telephone directory. Also write for complete index of design and fabrication literature. Reynolds Metals Co., 2561 S. Third Street, Louisville 1, Kentucky.

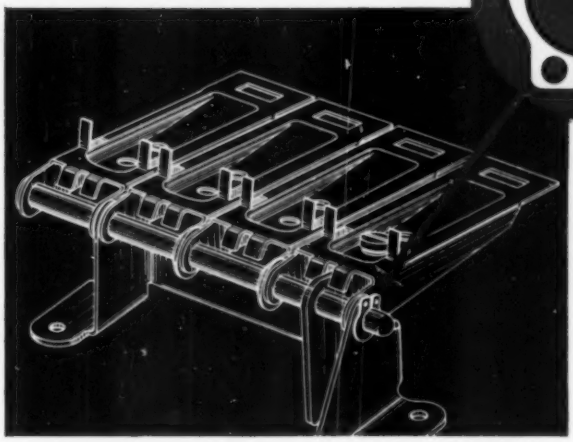
*Standard Equipment on Crown Imperial Models

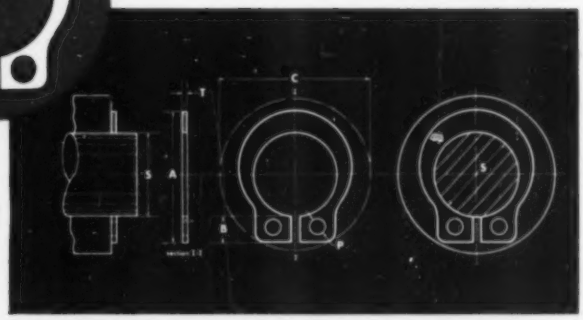
See "*Mister Peepers*" on NBC-TV. Consult local listings for time and station.

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

New Waldes Truarc GRIP Ring requires no groove, holds fast by friction, can be used over and over again





Ring # 5355		5355-12	5355-13½	5355-18	5355-25	5355-31	5355-37
SHAFT DIAMETER	Fract. Equiv. S	1/8"	—	3/16"	1/4"	5/16"	3/8"
	Dec. Equiv. S	.125	.136	.187	.250	.312	.375
	TOL.	±.002	±.002	±.002	±.002	±.003	±.003
RING DIMENSIONS	Thickness T	.025	.025	.035	.035	.042	.042
	TOL.	±.0015	±.0015	±.002	±.002	±.002	±.002
	Length A	.268	.285	.364	.437	.553	.626
	Lug B	.078	.078	.097	.097	.141	.141
	Hole P	.042	.042	.042	.042	.078	.078
	Min. Ring Clear C	.33	.34	.44	.50	.67	.73
Approx. Ultim. Thrust Load (Lbs)		20	20	25	35	50	60

The Waldes Truarc Grip Ring is a new, low cost fastener that provides a positioning shoulder secure against moderate thrusts or vibration. Installed on a straight ungrooved shaft, the Truarc Grip Ring can be assembled and disassembled in either direction with Truarc pliers.

The Grip Ring can be installed tightly against a machine part in order to take up end-play. The basic Truarc design principle assuring complete circularity around periphery of the shaft and the ring's unusually large radial width combine to exert considerable frictional hold against axial displacement. The ring can be used again and again.

Find out what Waldes Truarc Retaining Rings can do for you. Send us your drawings. Waldes Truarc engineers will give your problems individual attention without obligation.

SEND FOR NEW CATALOG

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,949; 2,416,852; 2,420,921; 2,420,341; 2,439,705; 2,441,846; 2,455,168; 2,483,300; 2,483,303; 2,487,803; 2,487,903; 2,491,306; 2,509,091 AND OTHER PATENTS PENDING.

Waldes Kohinoor, Inc., PN-115
47-16 Austel Place, L.I.C. 1, N. Y.

☐ Please send me sample Grip-Rings (please specify shaft size _____)

☐ Please send me the complete Waldes Truarc catalog.

(PLEASE PRINT)

Name_____

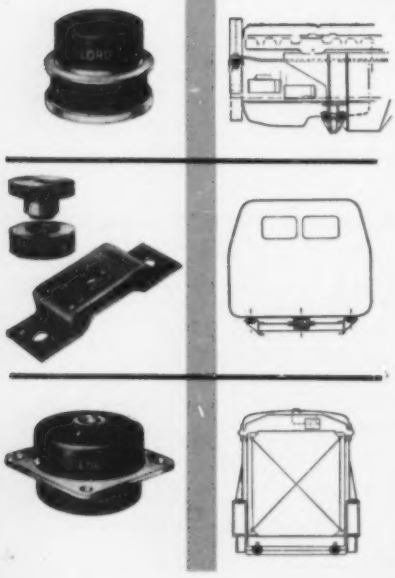
Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

LORD Bonded-Rubber Mountings... As Rugged As This



The world's largest "off-the-road" truck, Model 60 Dart, hauls 60 tons of copper ore from the huge shovels in the pits of The Bagdad Copper Mines of Bagdad, Arizona to the mine rim over tortuous, twisting, climbing roadways impossible for any other means of transportation. Contributing to the desired performance of this mammoth vehicle, Lord Bonded-Rubber Mountings cushion the twin radiators against vibration and shock, thus protecting the vital cooling system and reducing maintenance costs.

The two 350 hp. diesel engines and transmission assemblies are protected from the shocks of rough going by Lord Mountings . . . these same mountings provide a barrier between damaging engine vibration and the truck itself. To complete the job Lord Mountings protect the cab.

As rugged as the products they protect, Lord Bonded-Rubber Parts are used every day to improve the performance of industrial products large and small . . . Let us work with you.

BURBANK, CALIFORNIA 233 South Third Street
DALLAS, TEXAS 413 Fidelity Union Life Building
PHILADELPHIA 7, PENNSYLVANIA 725 Widener Building
DAYTON 2, OHIO 410 West First Street
DETROIT 2, MICHIGAN 311 Curtis Building
NEW YORK 16, NEW YORK 280 Madison Avenue
CHICAGO 11, ILLINOIS 520 N. Michigan Ave.
CLEVELAND 15, OHIO Room 811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

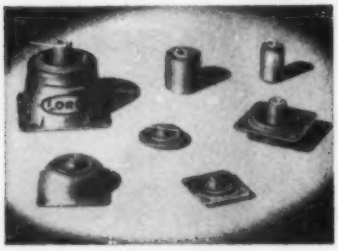
Headquarters for **VIBRATION CONTROL**

(Advertisement)

Lord Vibration Control Mountings . . . The Most Effective Protection For Electronic Equipment

In the rapidly advancing field of electronics, the control of destructive vibration and isolation of damaging shock are prime factors in the consideration of design engineers. Lord, Headquarters for Vibration Control, is constantly working with electronics engineers to improve the methods for protecting sensitive mechanisms.

For instance, Varo Static Converters which change alternating to direct current for aircraft with less than 1% voltage ripple are protected against shock and vibration by Lord Mountings. High fidelity Audio frequency electronic equipment such as Collins Radio Company manufactures is protected from vibration and shock through the use of Lord Mountings. The 212A-1 Broadcast Station Speech Input Console by Collins requires 28 Lord square Plate Form Mountings to protect each amplifier stage individually. This prevents mechanical interaction between stages and lessens acoustical feed-back effects.



Again the Agnew Spark Plug Welder by Agnew Electric Company uses Lord Mountings to support the electronic weld timers to prolong the useful service life of Mercury Vapor Tubes.

Lord Mountings, which you see illustrated in the accompanying advertisement, are used in a wide diversity of applications to protect electronic equipment and sensitive instruments. Business machines and such sensitive mechanisms, the accuracy of which must be perfect, are improved in operation and protected from damaging vibration and shock by Lord Mountings.

The Lord Manufacturing Company, Erie, Pa., offers a vast reservoir of recorded experience in the solution of vibration and shock problems. Your request for help on your own problem is welcomed.

SENSITIVE electronic equipment for airline transmitting and receiving must give continuously accurate results. For instance, note this "inside" view of the Collins Transceiver, mounted on Lord Temproof Mountings which isolate it from vibration and shock. Lord Temproof Mountings function efficiently throughout operational ranges of temperature from —80° to +250°F. The Collins Transceiver with automatically tuned elements for maximum flexibility and high power output delivers maximum performance in any weather, completely protected from vibration, shock and excessive equipment motion at resonant frequencies by Lord Temproof Mountings.

May we give you further details on this Lord application or help you solve your specific mounting requirement?

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DALLAS, TEXAS — 413 Fidelity Union Life Building
PHILADELPHIA 7, PENNSYLVANIA — 725 Widener Building
DAYTON 2, OHIO — 410 West First Street
DETROIT 2, MICHIGAN — 311 Curtis Building
NEW YORK 16, NEW YORK — 280 Madison Avenue
CHICAGO 11, ILLINOIS — 520 N. Michigan Ave.
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LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER — *Headquarters for* VIBRATION CONTROL

"We expect 20 years of service or *more* from these American Quality Springs"

...says SIMMONS COMPANY, World's largest producer of sleeping equipment

EVERY housewife in America knows that the name *Simmons* is an ironclad guarantee of quality when it appears on a mattress or sofa.

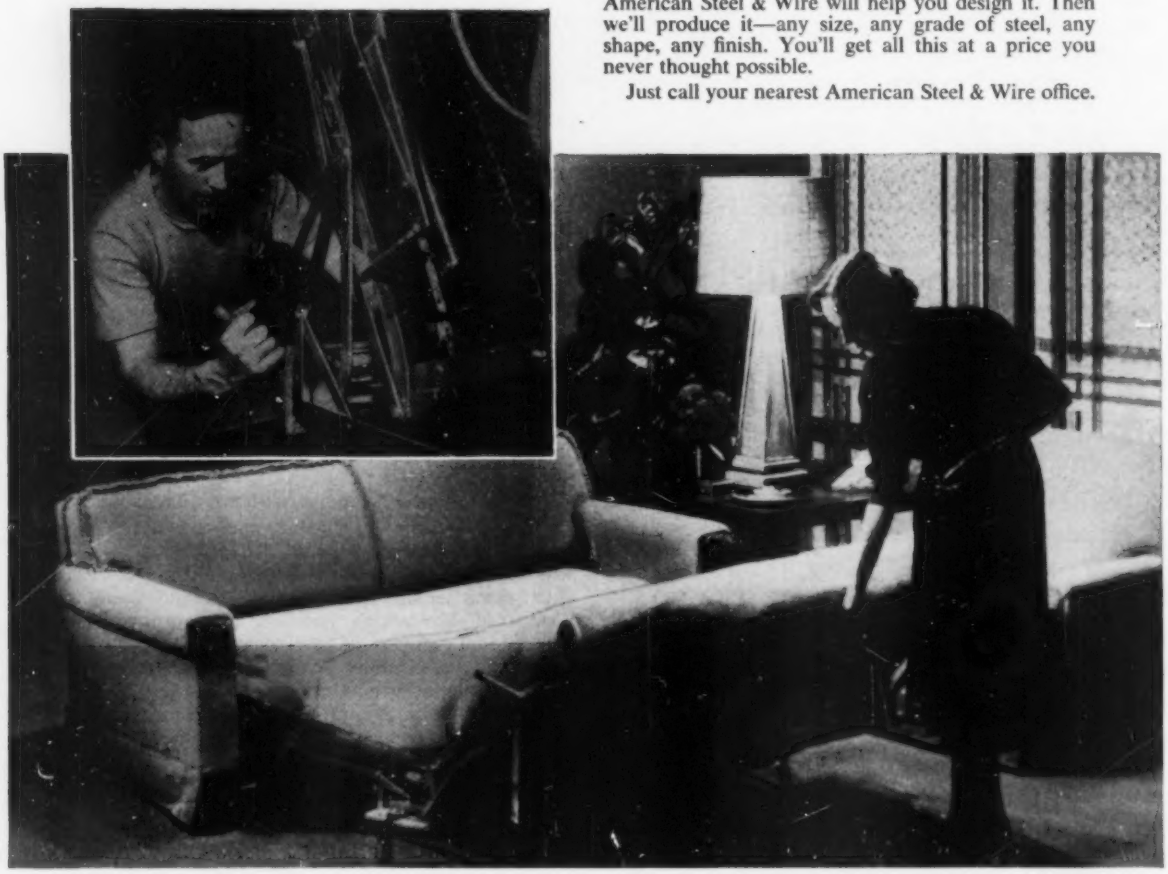
If you visited any of the 7 Simmons factories, you'd know why. Simmons has built an unparalleled reputation by *insisting* on fine workmanship and highest quality component parts.

Look at the famous Hide-A-Bed shown here. You don't have to yank and pull to open it into a comfortable bed. It glides open easily on 6 counter-balance American Quality Springs. Each of these 9-inch springs must withstand a stretch to 15 inches. In a 20-year period, these 6 helical springs are stretched to the limit 14,600 times.

We produce these springs for Simmons using a high-grade oil-tempered wire. As a result, the finished springs meet very close load tolerances, and they are consistently straight.

If you need a typewriter spring, an automobile axle spring, or a spring to support a giant locomotive, American Steel & Wire will help you design it. Then we'll produce it—any size, any grade of steel, any shape, any finish. You'll get all this at a price you never thought possible.

Just call your nearest American Steel & Wire office.



AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
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USS

U·S·S American Quality Springs

UNITED STATES STEEL

This fastener works through thick and thin!

Spring-Lock—the easy-to-use removable fastener for modern designs—works whether panel thicknesses run over or under specifications! Spring wire deflects automatically to handle greater or lesser thicknesses. Spring-Lock's design flexibility makes it more than a fastener: it can be adapted as a shelf support, door strike, knob or any similar panel-mounted device. Many standard shapes and sizes of Simmons Spring-Locks are available from stock.

SIMMONS FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT!

HERE'S HOW SPRING-LOCK WORKS

1. *Insert fastener.*

2. *Half-turn locks it in place.*

With production costs on the uptrend, you can figure on Spring-Lock as an assembly time and money-saver, because:

- **Installation is BLIND**
- **Installation is EASY: no special tools are needed**
- **Installation is QUICK: a half-turn locks it in place**
- **Installation is SECURE: the *spring* steel *locks* the fastener, resists vibration**

Send for details and samples, or write us about *your* fastening problem.

DUCTILE IRON GEARS provide *Superior Strength* with *Excellent Resistance to Wear*

Large Gears... such as these Ductile Iron girth gears drive large tube mills in the cement and mining industries. Put into service without heat treatment, they normally provide 92,000 to 100,000 psi ultimate tensile strength, 3 to 5% elongation, and 270-290 BHN on the tooth surface.

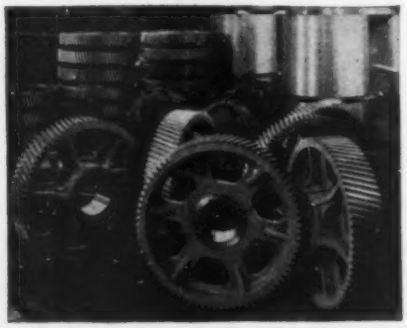
In addition to excellent castability, ready machinability and moderate cost, Ductile Iron offers properties that are vital in a gear material.

For along with high strength and measurable ductility, Ductile Iron "as cast" combines good resistance to wear and galling, with superior values for notched endurance limits.

Ductile Iron can be heat treated to provide tensile strengths of over 150,000 psi. It develops surface hardnesses of over 600 BHN after flame or induction hardening. Service data show also that annealed Ductile Iron develops impressive properties which result in peak performance.

Ductile Iron can provide a chilled, carbidic, abrasion-resistant surface supported by a tough ductile core. No other single material combines these properties. Still another advantage is its ability to damp out vibrations that otherwise might build up stresses to dangerous levels.

Send us details of your prospective uses, so that we may suggest a source of supply from some 100 authorized foundries now producing Ductile Iron under patent licenses. Request a list of available publications on Ductile Iron ... mail the coupon now.



Medium Gears produced in heat treated Ductile Iron have replaced steel gear castings and forgings in papermaking and allied equipment. Annealed Ductile Iron can be machined at a rate of 2 to 3 times that of good quality gray iron of comparable hardness.

The International Nickel Company, Inc.
Dept. 20, 67 Wall Street, New York 5, N. Y.

PE-11-53

Please send me a list of publications on: **DUCTILE IRON**

Name_____ **Title**_____

Company_____

Address_____

City_____ **State**_____

Small Gears... also worms... exemplify an application of Ductile Iron in the railroad field.

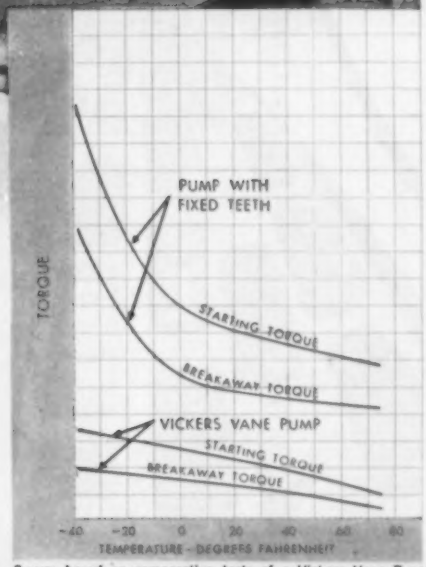
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

When Tractor Hydraulic System has a VICKERS® Balanced Vane Type Pump

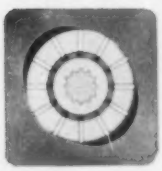
Under the very best conditions, cold weather puts a strain on starting equipment. Every part of the engine is stiffer, and the cold seriously decreases the power of the starting battery. If the hydraulic system has a pump with fixed teeth or lobes, this starting load may be seriously increased above normal.

Vickers Balanced Vane Type Pumps *start at practically no load.* At rest and at normal starting speeds, the sliding vanes are retracted . . . only after the engine fires do the vanes extend and pumping begins. As a result, cold weather starting is much easier when a Vickers Vane Type Pump is used.

Get in touch with the nearest Vickers office for full information.

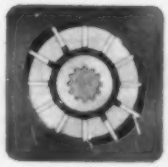


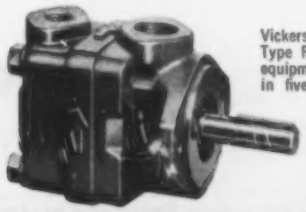
Curves based on comparative tests of a Vickers Vane Type Pump and an equal capacity pump with fixed teeth. Oil used in both was SAE 10W premium grade.



(Left) Schematic diagram of Vickers Balanced Vane Type Pump showing how sliding vanes are retracted at normal engine cranking speeds. No oil is pumped and there is practically no starting load.

(Right) Similar diagram of Vickers pump showing how pump vanes are extended when engine is running. Pumping then begins and continues at all engine speeds.





Vickers Balanced Vane Type Pumps for mobile equipment are available in five basic sizes, 15 normal delivery ratings and a variety of mountings. Ask for new Catalog M-5101.

6628

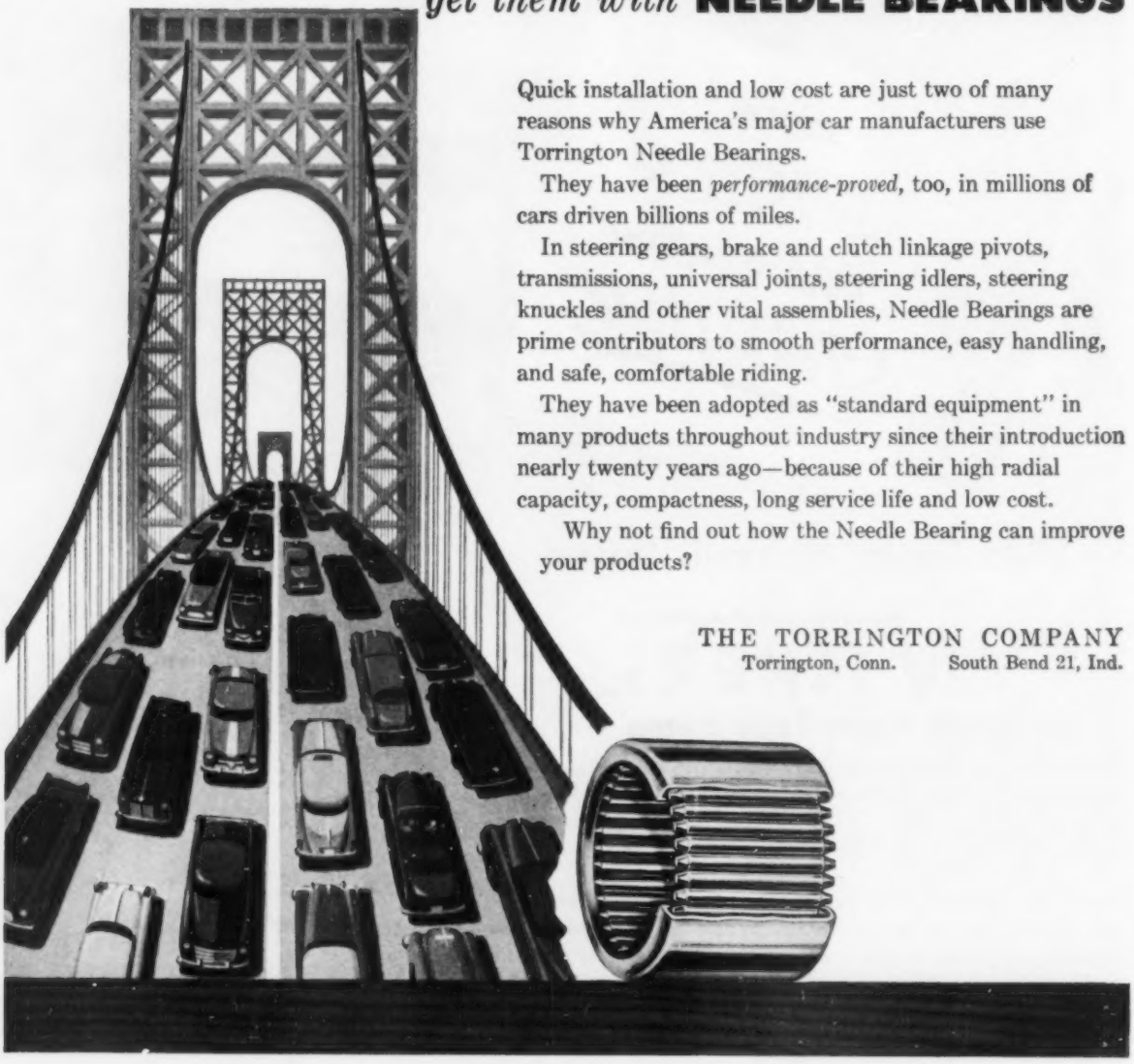
VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1454 OAKMAN BLVD. • DETROIT 32, MICH.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) • CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) NEW YORK (Metropolitan) • PHILADELPHIA (Metropolitan) • PITTSBURGH • ROCHESTER • ROCKFORD • SEATTLE • TULSA • WASHINGTON • WORCESTER

Are Easy Assembly and Low Cost "Musts" for You?

Here's how leading automobile manufacturers get them with NEEDLE BEARINGS



Quick installation and low cost are just two of many reasons why America's major car manufacturers use Torrington Needle Bearings.

They have been *performance-proved*, too, in millions of cars driven billions of miles.

In steering gears, brake and clutch linkage pivots, transmissions, universal joints, steering idlers, steering knuckles and other vital assemblies, Needle Bearings are prime contributors to smooth performance, easy handling, and safe, comfortable riding.

They have been adopted as "standard equipment" in many products throughout industry since their introduction nearly twenty years ago—because of their high radial capacity, compactness, long service life and low cost.

Why not find out how the Needle Bearing can improve your products?

THE TORRINGTON COMPANY
Torrington, Conn. South Bend 21, Ind.

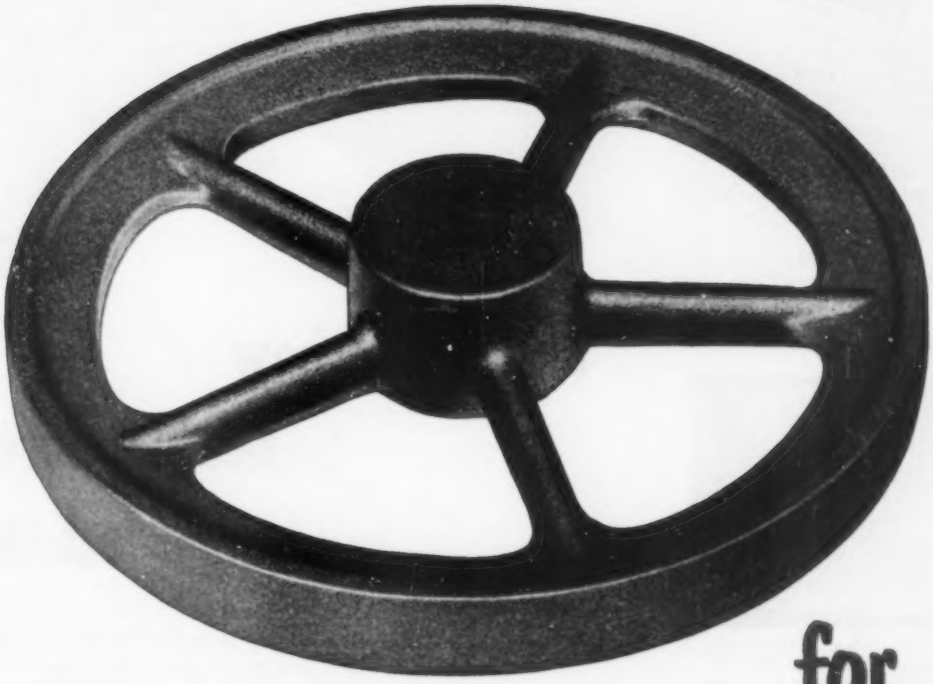
TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

Trade Marks of 12 of the 18 passenger car manufacturers, all of whose cars enjoy the benefits of Needle Bearings.

STUDEBAKER · CHRYSLER · PONTIAC · Packard · DeSoto · WILLYS · Nash · KAISER · LINCOLN · Ford · MERCURY

Eaton Permanent Mold Gray Iron Castings—



for

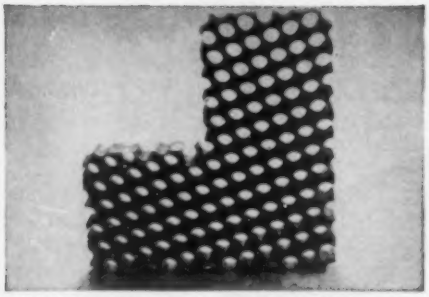
V-BELT PULLEYS

Send for your free copy of the 32-page illustrated booklet: "The Eaton Permanent Mold Foundry." It tells the story of Permanent Mold Castings and takes you on a picture-tour of the Eaton Foundry at Vassar, Michigan.

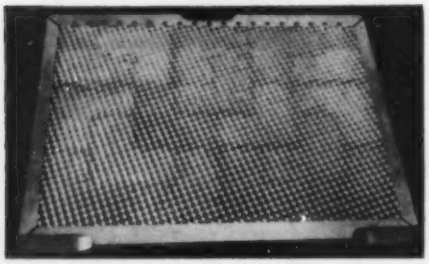
EATON MANUFACTURING COMPANY
General Offices: CLEVELAND, OHIO
FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Here's a honey

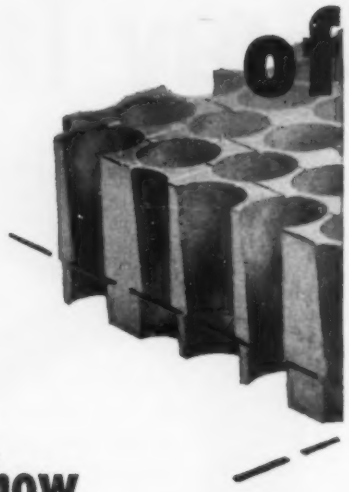


This is the "L"-shaped die cast unit just as it comes from Doehler-Jarvis machines. It is 5" x 5" on the long sides, 2½" on the four short sides and is ¾" thick. Prior to Base assembly at the Blatchford plant, flash is removed from the edges, and top and bottom are shaved slightly. No other finishing is needed . . . thanks to Doehler-Jarvis die-casting methods.



Here is a complete Blatchford "Honeycomb" Base with inside chase dimensions of 15" x 20". (Unit assembly of these Bases makes possible sizes up to 50" x 75".) It is made up of 16 of the angle blocks held together only by the enormous pressure of the chase bars – bolted at the corners – that frame the base. Surface of the form must be absolutely flat without even a few thousandths buckle or warp. Holes must line up precisely. Doehler-Jarvis die castings make possible perfect fit and virtually invisible joints in assembly of Base units.

Stonehands position and anchor printing plates on the "Honeycomb" Base with special catches that fit and expand in the holes. The thin walls of the Doehler-Jarvis castings have to be strong and solid to withstand both the locking pressure and the gripping forces exerted by the catch. When the plate mounting is completed, the entire "locked-up" form goes to the printing press.



of

and here's how Doehler-Jarvis perfect this

Before this intricate section was perfected, E. W. Blatchford Co. had to overcome some real production headaches.

To machine their lightweight "Honeycomb" plate mounting system for printers would have been prohibitively costly. They would have had to remove 71% of the metal volume in the component blocks. And no one could agree on a way to form the partial holes along the "block" edges without running up rejects and tool breakage.

Then someone suggested die casting... a production technique that was just beginning to get wide attention 35 years ago. Die casting proved to be the practical answer but Blatchford engineers were still not completely satisfied. The behavior of the alloy was not always predictable and warpage of the "blocks" occasionally caused trouble.

Then Doehler-Jarvis entered the picture and worked the problem over with Blatchford people.

That did it. Quality went up and product performance improved. Over the years Doehler-Jarvis cast untold thousands of the "honeycomb" units. Printers bought Blatchford "Patent Base" like hotcakes... under Blatchford's 10-year guarantee.

Then, just a few years ago, Blatchford wanted to make the Base even lighter on men, even lighter on power, even lighter on presses. Again engineers from both companies joined forces. They put several light metal alloys to the toughest of tests.

How would *you* go about making this magnesium "honeycomb" block, with its partial holes, its thin sections, its precision requirements?

helped Blatchford complex component

A magnesium alloy finally was selected and Doehler-Jarvis designed and built a new production die.

Today, so precise is the Doehler-Jarvis casting technique, only 1/10 of an ounce – 1.82% of the as-cast weight – is removed in finishing the "Honeycomb" block. The new Magnesium Base weighs 72% less than the original Zinc Base. Needless to say, it too is winning its battle in the market place.

As one Blatchford executive puts it, "Doehler-Jarvis die castings helped get our Base over the hump in the first place, helped us stay competitive over the years, then helped us give the product a shot in the arm."

In its half-century of die-casting, Doehler-Jarvis has helped turn good ideas into metal for many producers, large and small – among them some of the best known makers of automotive, electrical, communication, household, office and other types of equipment.

When they come to Doehler-Jarvis, they know that Doehler-Jarvis can supply both the resources and the resourcefulness they need.

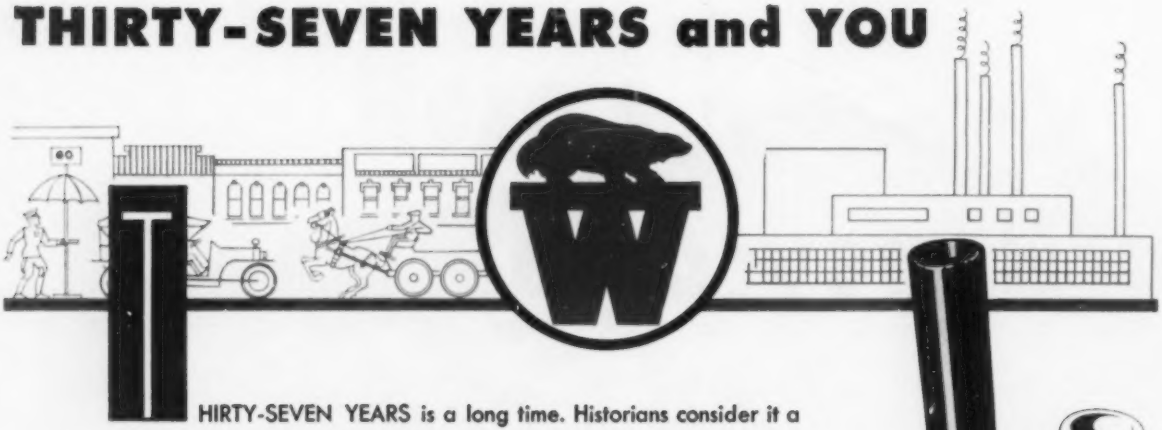
So next time you have a good new product idea... call Doehler-Jarvis in on the production engineering. We may be able to give you just the help you need.

Doehler-Jarvis Division
of
National Lead Company
General Offices: Toledo 1, Ohio

DOEHLER-JARVIS

*Reg. U. S. Pat. Off.

THIRTY-SEVEN YEARS and YOU



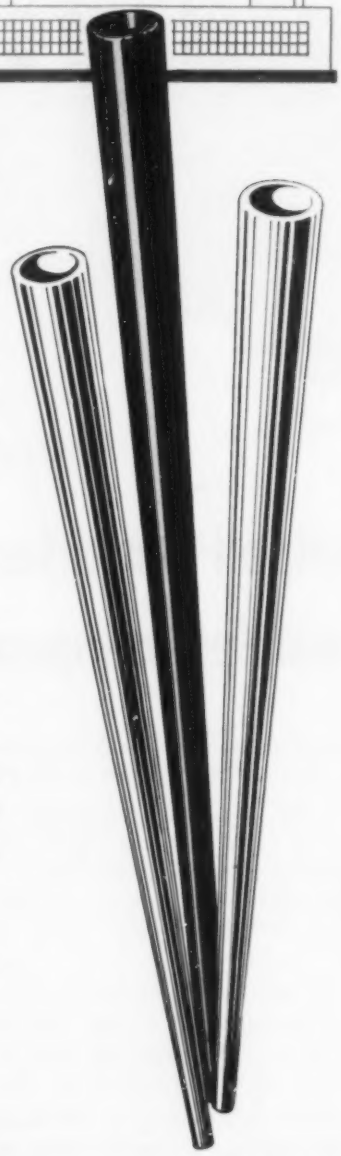
THIRTY-SEVEN YEARS is a long time. Historians consider it a generation. Many things happen in that length of time to change our lives. The passing years add experience that guides our forward steps.

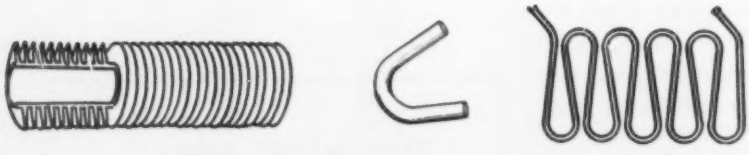
Since the start of our business, thirty-seven years ago, many changes have taken place here at Wolverine. Each has been a step forward—the natural result of experience that has been constantly furnishing the inspiration for us to keep looking ahead in search of better ways of doing things, in order that we may bring you the best tube products that human effort, skill, and modern equipment can provide.

Our efforts are not alone confined to the manufacture of tubing, but also to finding ways and means that will make the application of tube most practical—either in the original tube form or as a fabricated tubular part.

As tube specialists, we interest ourselves in both the production of the tube and its ultimate use. We feel it our responsibility to see that Wolverine tube functions to its fullest capacity. We know how to build the finest tube that skill and equipment can produce. And we can fabricate it in any shapes your specifications demand, from the following metals—copper, copper base alloys, electric-welded steel, and aluminum (2S or 3S).

It is reasonable to believe that our progress can help your progress.





WOLVERINE TUBE DIVISION
of CALUMET & HECLA, INC.

ESTABLISHED 1916

Manufacturers of Quality-Controlled Tubing

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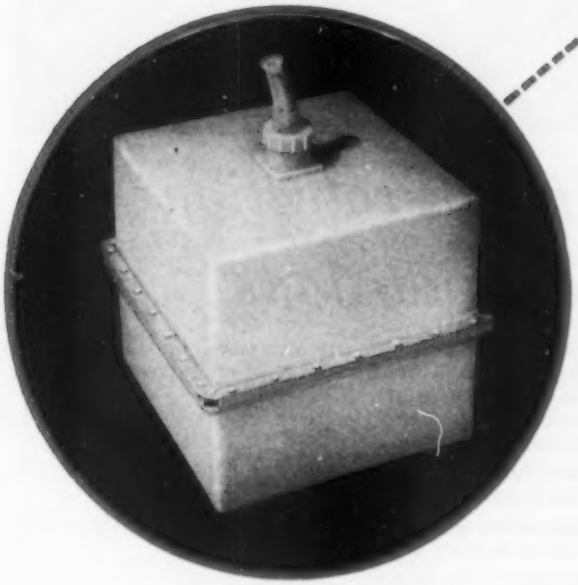
Plants in Detroit, Mich. & Decatur, Ala. *Sales offices in Principal Cities*

EXPORT DEPT. 13 E. 40th St. New York 16, N. Y.

New carboy container of Du Pont Alathon*



is light, tough, chemical-resistant

This new carboy offers improved utility and economy for the shipment and storage of corrosive chemicals. The 15-gallon inner container (complete with screw cap, seal and pouring spout) is molded of Du Pont "Alathon" polyethylene resin, yet weighs only 12 to 13 pounds. This saving in weight means easy handling, low shipping costs. The moldability of "Alathon" permits the square shape . . . means easy stacking and full use of shipping and storage space.

Du Pont "Alathon" has a low specific gravity (0.92) and exceptional resistance to chemical attack. "Alathon" is tough, resilient, virtually unbreakable—even at low temperatures. It contains no plasticizer . . . is non-contaminating. "Alathon" has a low rate of water-vapor transmission. And parts can be economically molded of "Alathon" by injection molding, cutting production time and costs.

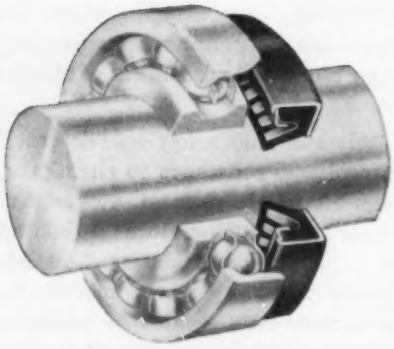
Other examples of the product design and improvement possible with Du Pont "Alathon" are squeeze bottles, battery parts, pipe, flexible housewares, toys, TV lead-in wire and cable insulation ("Alathon" also has excellent dielectric properties). Perhaps this combination of properties can help you. For full information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 1011A Du Pont Bldg., Wilmington 98, Delaware.

*REG. U. S. PAT. OFF.

Containers molded by
A. L. Hyde Co., Grenloch, N. J.,
for Tennessee Products & Chemical Corp.,
Nashville, Tenn.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY
Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

Dependable Bearing Protection for All Service Conditions



Model 53 KLOZURE, with standard sealing element, applied to a shaft to protect the ball bearing.

The true value of any oil seal must be measured by the ability of the sealing element to protect the bearing by keeping the lubricant *in*, dirt and moisture *out*.

For your bearing protection Garlock KLOZURES offer you these important sealing-element advantages:

1. **Synthetic rubber sealing elements** for oil, grease, water, mild acids and alkalies at temperatures up to 300° F.
2. **Silicone rubber sealing elements** for extremes of high and low temperatures.
3. **Teflon sealing elements** for strong acids.
4. **Choice of sealing element designs** with finger spring or garter spring for light, medium or heavy duty service at all speeds.
5. **All sealing elements** accurate and uniform in size, non-porous, tough, durable, non-abrasive and free-running.

Garlock KLOZURE Oil Seals are made in a complete range of sizes and in many models. For complete information call your Garlock representative or write for KLOZURE Catalog No. 10.

*Registered Trademark

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.
Branch Offices in Most Principal Cities

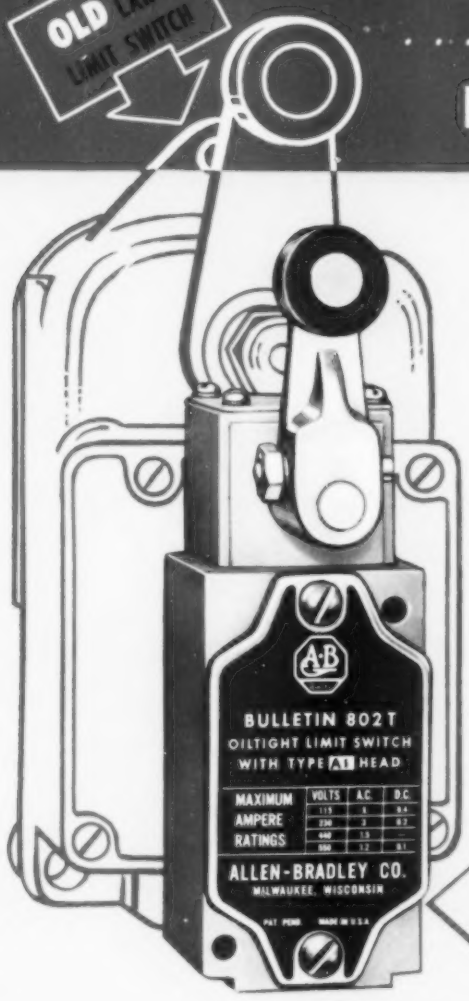
GARLOCK PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS, RUBBER EXPANSION JOINTS

OVERSIZE

IS OFTEN A HANDICAP

. . . . . *especially in*

LIMIT SWITCHES



Limit switches are intended for switching pilot circuits only. Hence, nothing is gained in making limit switches large and heavy. In fact, the excessive impact of high inertia, oversize parts may actually shorten the working life of the moving elements and contacts.

Look at the new, compact Allen-Bradley limit switch. Compare it with the old, oversize unit. The new limit switch has no useless bulk . . . no excess weight . . . yet it is good for millions of trouble free operations.

Quickly Adapted to Any Location . . .

The Bulletin 802T oiltight limit switch has double break, maintenance free, silver contacts.

Various operating heads are available with different types of push rods and levers. Limit switches in flush type construction can also be furnished.

The operating heads may be mounted in any one of four positions to fit any location on your machines. Since operating heads are interchangeable, the heads and bases may be stocked separately . . . and thus simplify your inventory problems.

NEW SMALL A-B LIMIT SWITCH

The Bulletin 802T oiltight limit switch is a real pacemaker in up-to-the-minute design and performance. It is rated for operation on alternating or direct current at 115, 230, 440, and 550 volts. If you use limit switches, by all means send for our illustrated Bulletin 802T which shows the various types of operating heads available for various limit switch applications.

A-B Quality

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wisconsin

ALLEN-BRADLEY
LIMIT SWITCHES

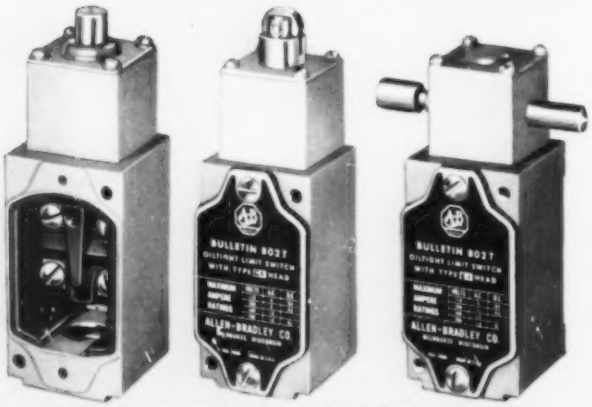
9-53-MR

OILTIGHT LIMIT SWITCHES

The Sign of Quality in Motor Control

The operating head, with lever or push rod, may be set in 4 horizontal locations, each 90 degrees apart.

A COMPLETE LINE OF COMPACT, DEPENDABLE LIMIT SWITCHES FOR OILTIGHT MACHINE TOOL SERVICE

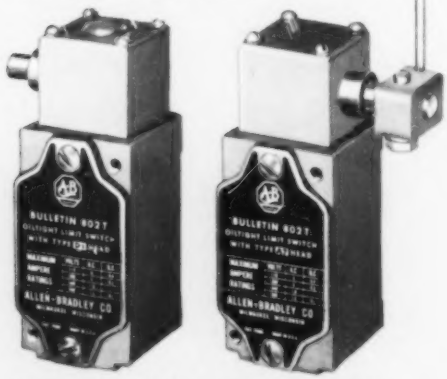


Operating heads are available with various push rods and levers. The switch is a single pole, snap acting unit, with one normally open and one normally closed contact, electrically separated. Most of these limit switches can be supplied for spring return or maintained contact operation.

The compact, streamlined design of these Bulletin 802T limit switches marks a new advance in motor control engineering.

The name plate cover has a synthetic rubber gasket to exclude oil. Terminals are easily accessible by removing the name plate. The switch body is threaded for ½ inch conduit. Let us send a sample for your inspection.

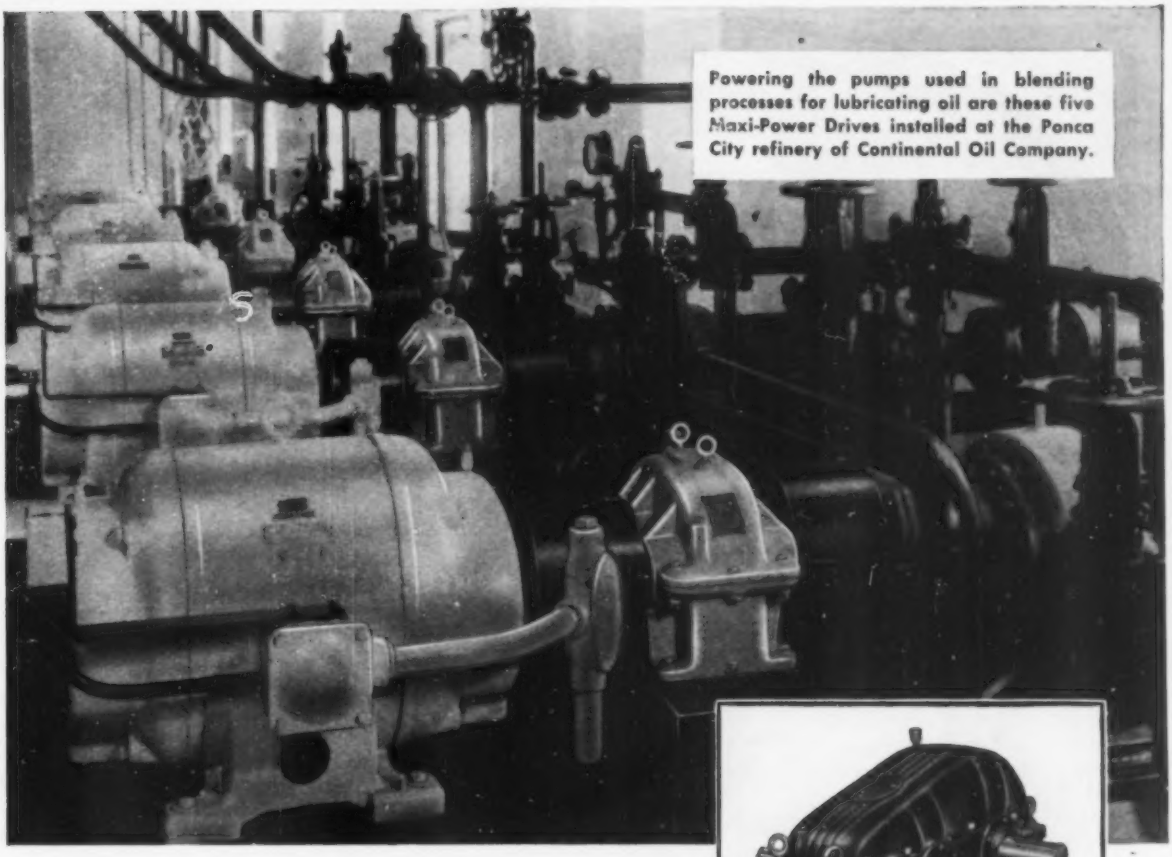
Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.



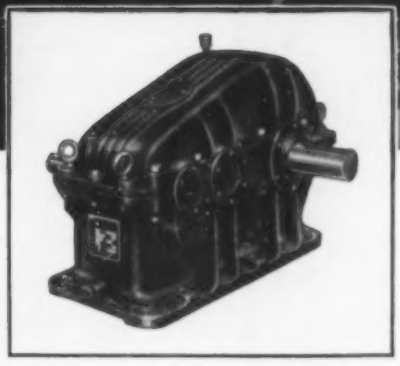
Bulletin 802T oiltight limit switches can be mounted from the front, using the two clearance holes shown above. For mounting from the back, two tapped holes are provided in opposite corners.

ALLEN-BRADLEY QUALITY LIMIT SWITCHES

9-53-MR



Powering the pumps used in blending processes for lubricating oil are these five Maxi-Power Drives installed at the Ponca City refinery of Continental Oil Company.



MAXI-POWER

They Thrive on Heavy Duty

This Trademark Stands for the Finest in Industrial Gearing

Any drive will do a good job the first day, but how will the record read after a month — a year — five years?

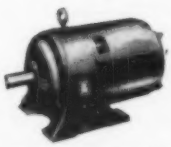
Will it — like Foote Bros. Maxi-Power Drives — still have the stamina to handle high horsepowers for hardest, day-after-day service? Will its maintenance costs remain low? Will efficiency still approach 100%?

And when you're deciding on a drive, is space a crucial factor? Maxi-Power's superior gearing is designed into the most compact housing to assure maximum load-carrying capacity in minimum space for heavy-duty units.

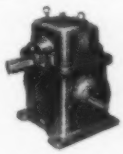
Sturdy — reliable — Maxi-Power Drives provide years of better performance for the most rugged applications. Available with single, double or triple reductions in sizes to meet your requirements. Ratios range up to 360 to 1, capacities up to 1,550 h.p.

Call your Foote Bros. representative, or write for detailed information.

Line-O-Power Drives



Foote Bros.-Louis Allis Gearmotors



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Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
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Please send Bulletin MPB containing full information about heavy-duty Maxi-Power Drives.

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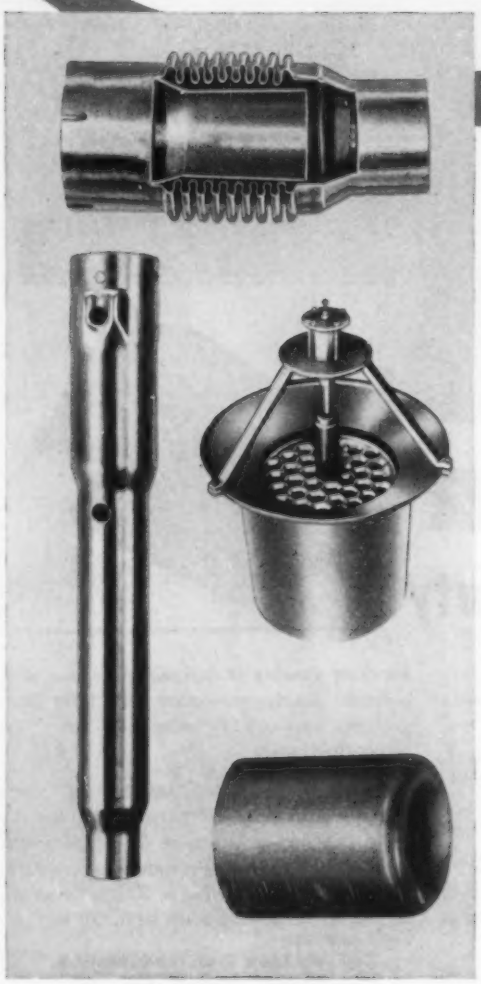
Company.....

Address.....

City..... Zone..... State.....

How to Design for More Product Efficiency



In the column at the left you'll see a few parts that may help you in your next design job. They demonstrate, somewhat, the possibilities of "design freedom" that come when you design with Carpenter Stainless Tubing in mind, because they show that modification of design to achieve economical working or fabrication is unnecessary when you specify "Carpenter".

In short, Carpenter stainless gives you those working properties that make for easy fabrication and low reject rate even when severe drawing, swaging, flanging or upsetting are required. In addition, Carpenter is delivered "as specified" in analysis, dimension, finish, tolerance and temper, piece after piece, order after order. It does not vary in quality.

Why not design the cost-saving advantages of Carpenter tubing into your products. Call your nearest Carpenter representative—and prove for yourself that there is no "or equivalent" for Carpenter quality in stainless tubing.

The Carpenter Steel Company, Alloy Tube Division, Union, N.J.

Branch Offices: Atlanta Chicago Pittsburgh Houston Newark San Francisco

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Carpenter

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Analysis · Tolerance · Finish

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NATIONAL OIL SEAL LOGBOOK

Write our Redwood City office for reprints of this Logbook page

Sealing News & Tips

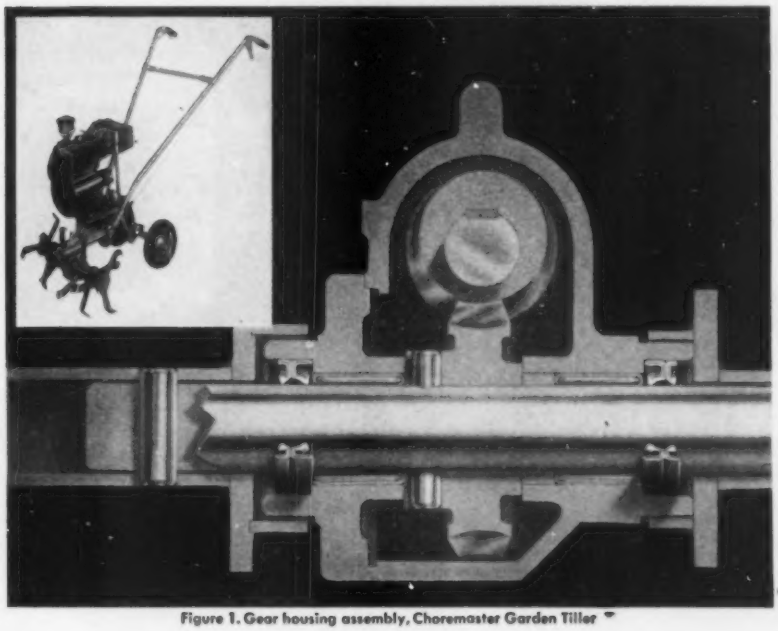

Figure 1. Gear housing assembly, Choremaster Garden Tiller

How National Syntech* Oil Seals halt leakage, exclude dirt from Choremaster Garden Tiller

In the Choremaster Garden Tiller, tines are driven and the machine propelled through a worm gear assembly at the front of the unit. Dirt, dust and mud pack heavily around this forward gear box (Figure 1), making it difficult to achieve 100% exclusion of foreign matter and zero leakage of lubricant without unacceptable loss of power.

After other sealing methods failed, two National Syntech (synthetic rubber) Oil Seals were installed back to back at either side of the gear box. A National 340,000 springless seal was faced outward to exclude dirt and a spring-tensioned National 350,000 seal was faced inward to retain gear oil. Immediately, the small investment in precision National seals paid off. Positive dirt exclusion and zero leakage were achieved. And, thanks to the knife-edge, low-friction Syntech sealing lip, there was almost no loss in power.

National Syntech Seals are used in a wide variety of applications, including those with speeds to 3,600 F.P.M., temperatures to 300°F and runout to .030 indicator reading. National Oil Seals have helped many manufacturers increase performance, lengthen life, or make products easier to assemble or service. Next time you need oil seal information or engineering help, why not call the National Applications Engineer nearest you?

340,000 Syntech

350,000 Syntech

*T. M. Reg.

In the Choremaster Tiller, National Applications Engineers helped solve a problem by utilizing two of 2,500 standard-design National Oil Seals.

Catalog 102-A (available on request giving name and title) lists most National seals—springless and spring-tensioned, single and dual lip, shaft and external, leather or synthetic rubber. In most cases one or more of these standard designs will give efficient, low-cost sealing. If special operating conditions, space limitations or other features rule out use of these standard-design seals, modified or special seals can be engineered. Your nearest National Applications Engineer has full information; or, write direct.

National, a leader in oil seals, also offers a complete quality line of commercial grade O-Rings in all standard sizes. Write for new National O-Ring catalog which lists all O-Rings, includes information on design, applications, performance, back-up rings, etc.

"Let Your Decision be Based on Precision"

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS

NATIONAL MOTOR BEARING CO., INC.
General Offices: Redwood City, California
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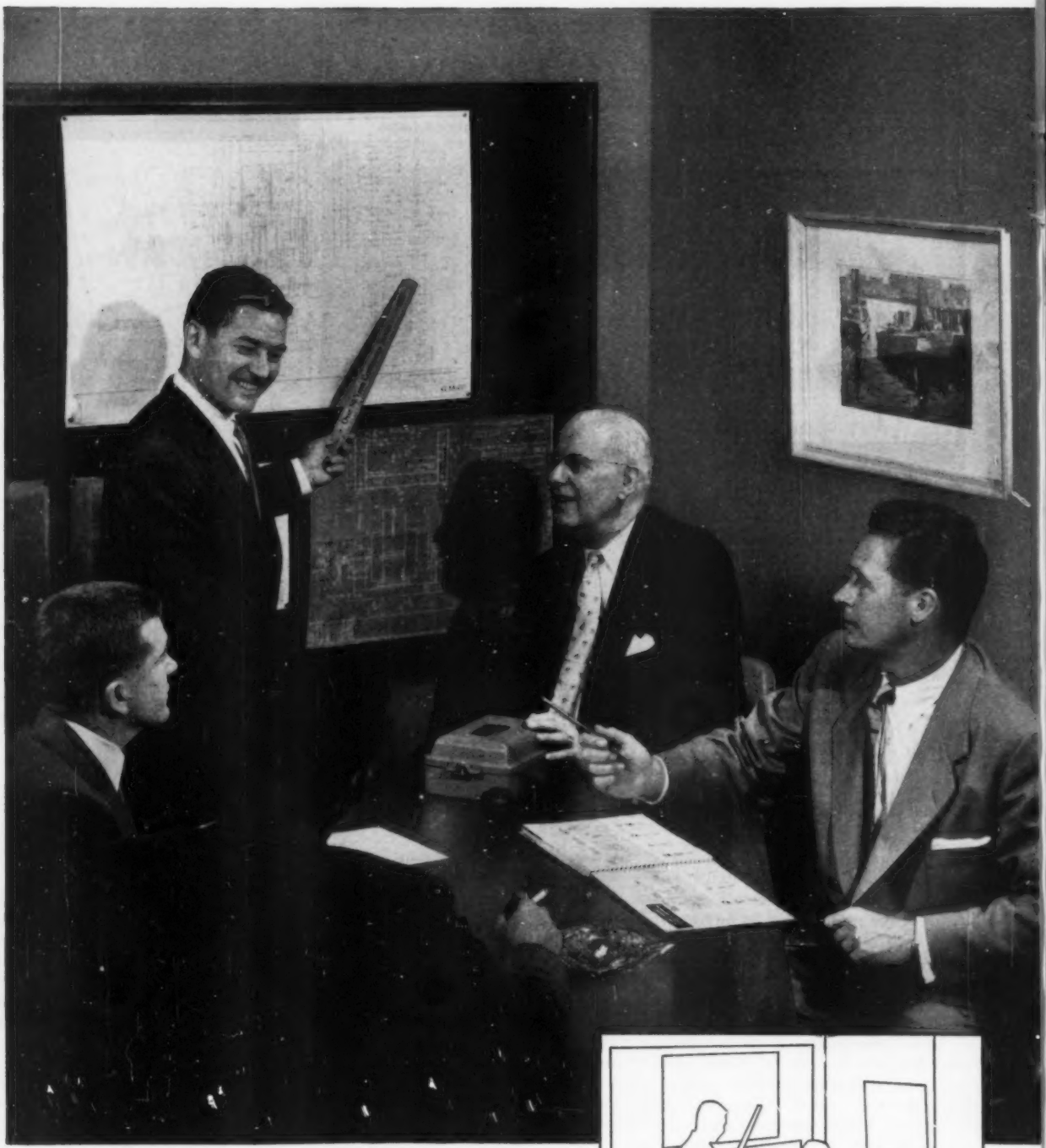
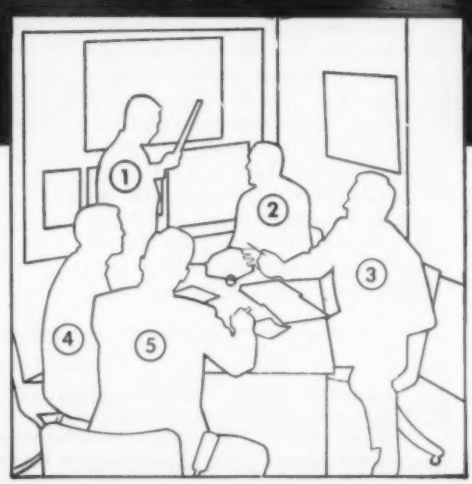


1. Westinghouse Application Engineer
2. Westinghouse Sales Engineer
3. Chief Engineer
4. Electrical Engineer
5. Production Superintendent



Your motor and control problems are local . . . so is Westinghouse application assistance

Do you put a full team on the field when you tackle a motor and control application problem? Are you cashing in on the know-how of your local staff of Westinghouse application engineers? Take a look at this line-up:

Your local Westinghouse sales engineer has a broad knowledge of all Westinghouse Motors and Controls. He knows their capabilities and limitations. He knows how to match motors and controls for maximum production.

Your local Westinghouse application engineer is equipped to analyze any motor and control problem and then develop the best solution. He can handle any application problem from a simple machine tool to a complete production line.

Your local Westinghouse product engineer is a specialist in one type of motor or control. These men work at the local level but operate from a manufacturing headquarters office.

Enlist the services of these men on your next motor and control application job. Call your local Westinghouse office for further details, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21746

Application engineers work out of 126 Westinghouse offices

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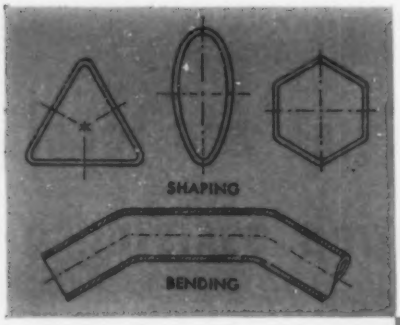
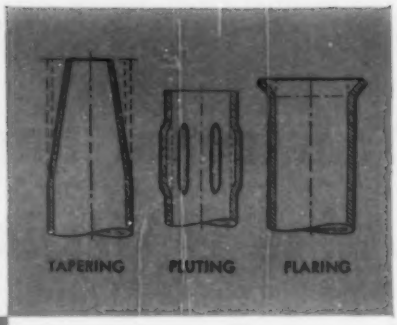
San Francisco 8, Cal.	EXbrook 2-5353
Seattle 4, Wash.	MAin 0808
Shreveport, La.	4-5298
Sioux City 4, Iowa	5-7634
South Bend 4, Ind.	3-7167
Spokane 8, Wash.	MAin 3294
Springfield, Ill.	3-1532
Springfield 3, Mass.	6-8373
Syracuse 4, N. Y.	2-1361
Tacoma 2, Wash.	BRoadway 6565
Tampa 1, Fla.	2-7246
Toledo 4, Ohio	GArfield 4525
Trenton 10, N. J.	2-4136
Tulsa 3, Okla.	3-3191
Utica 1, N. Y.	4-1194
Walla Walla, Wash.	5124
Washington 6, D. C.	NAtional 8-8843
Waterloo, Iowa	4579
Watertown, N. Y.	1400
Wheeling, W. Va.	6222-6223
Wichita 2, Kansas	5-2631
Wilkes-Barre, Pa.	3-1144
Williamsport, Pa.	4289
Worcester 8, Mass.	4-2648
York, Pa.	7851
Youngstown 3, Ohio	4-1118

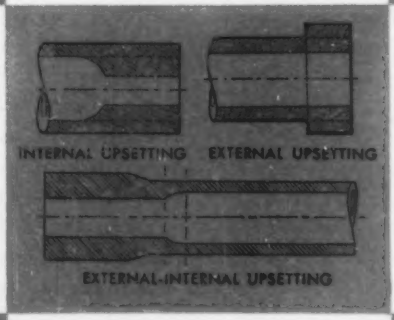
YOU CAN BE SURE...IF IT'S Westinghouse



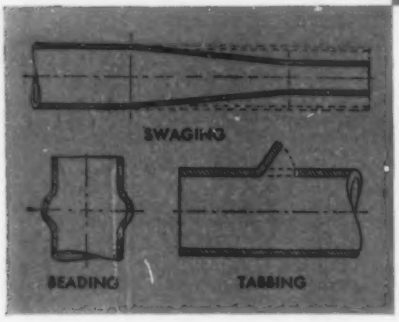
OSTUCO TUBING is versatile!



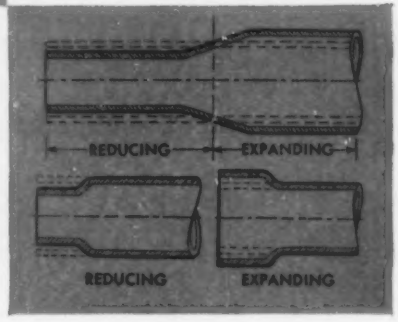
OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!



you draw the blueprint...we'll deliver the goods

There's practically no limit to the things OSTUCO can do with Seamless and Electric Welded Steel Tubing to help you produce lighter, stronger, better looking products at lower cost. Only a few of the operations are shown above.

Newly expanded and modernized facilities for *manufacturing, forging,* and *fabricating* tubing, all in one plant — plus our own steel source as a member of the Copperweld family —speed deliveries, assure highest quality and save you money.

Tubing is our business, not a side line. OSTUCO's unique "Single Source" operation, with unified production control, eliminates shipments from one location to another . . . greatly reduces rejects . . . prevents errors . . . puts an end to buck passing and red tape. You write one order, get one bill, and responsibility is clearly fixed. Write for informative catalog, "Ostuco Tubing."

From Your Blueprint . . . to Your Product
OSTUCO TUBING
Tapering • Swaging • Flanging • Bending
Upsetting • Expanding • Reducing • Beading
End closing • Spinning • Drilling • Slotting
Notching • Flattening • Shaping • Trimming
Threading • Angle Cutting • And Many Others

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company
Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing
Plant and General Offices: SHELBY, OHIO

OSTUCO SHELBY, OHIO

SALES OFFICES: Birmingham, P. O. Box 2021 • Chicago, Civic Opera Bldg., 20 N. Wacker Dr. Cleveland, 1328 Citizens Bldg. • Dayton, 511 Salem Ave. • Detroit, 520 W. Eight Mile Road, Ferndale • Houston, P. O. Box 17007 • Los Angeles, Suite 300-170 So. Beverly Drive, Beverly Hills • Moline, 617 15th St. • New York, 70 East 45th St. • Philadelphia, 2004 Packard Bldg., 15th & Chestnut • Pittsburgh, 1206 Pinewood Drive • St. Louis, 1230 North Main St. • Seattle, 3104 Smith Tower • Syracuse, 2350 Bellevue Ave. • Tulsa, 245 Kennedy Bldg. • Wichita, 622 E. Third St. • *Canadian Representative:* Railway & Power Corp., Ltd.

Helping to make fun of washday

Best day of the week? Washday, of course! Just ask any housewife who is lucky enough to have an automatic washer around the house.

Building these work-saving units so they will operate under many varied conditions is no simple task. Not only must manufacturers be sure of their design, they must also be sure of the materials they specify to do the job.

For example, when Hotpoint engineers developed a "fluid-drive" clutch assembly for their automatic washer, they found it necessary to join together a clutch face and an aluminum die casting. They called on 3M to tackle this bonding problem. 3M solved it with EC-1099—a fast-drying adhesive, noted for its high strength and its high resistance to oil and fuels.

See what adhesives can do for you...

Joining dissimilar materials is but one of many jobs 3M adhesives can do for you. For the complete story, contact your 3M sales representative. Or, write for free booklet to 3M, Dept. 411, 417 Piquette Ave., Detroit 2, Mich.

see our catalog in PRODUCT DESIGN FILE or write for copy

3M COMPANY

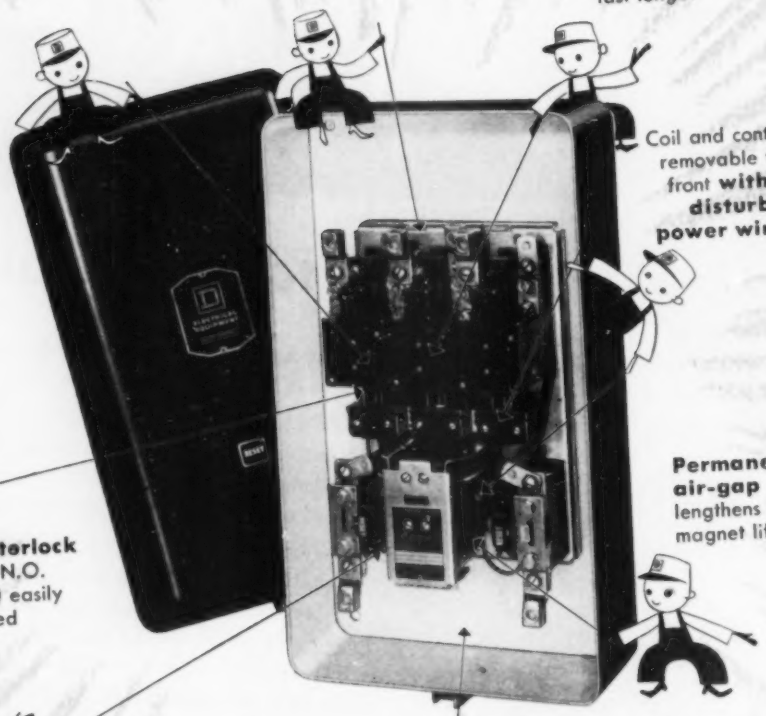
ADHESIVES • COATINGS • SEALERS

MINNESOTA MINING AND MANUFACTURING COMPANY
ADHESIVES AND COATINGS DIVISION • 417 PIQUETTE AVE., DETROIT 2, MICHIGAN
GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 122 E. 42 ST., N.Y. 17, N.Y. • CANADA: LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

Feature-packed SIZE 4 STARTER

LATEST ADDITION Balanced



"Hook-on" base design saves installation time and money

Special sintered metal contacts last longer

High arc-interrupting capacity with "magnetic yoke" arc chamber

Coil and contacts removable from front **without disturbing power wiring**

Permanent air-gap lengthens magnet life

Up to 8 interlock circuits (4 N.O. and 4 N.C.) easily front-mounted

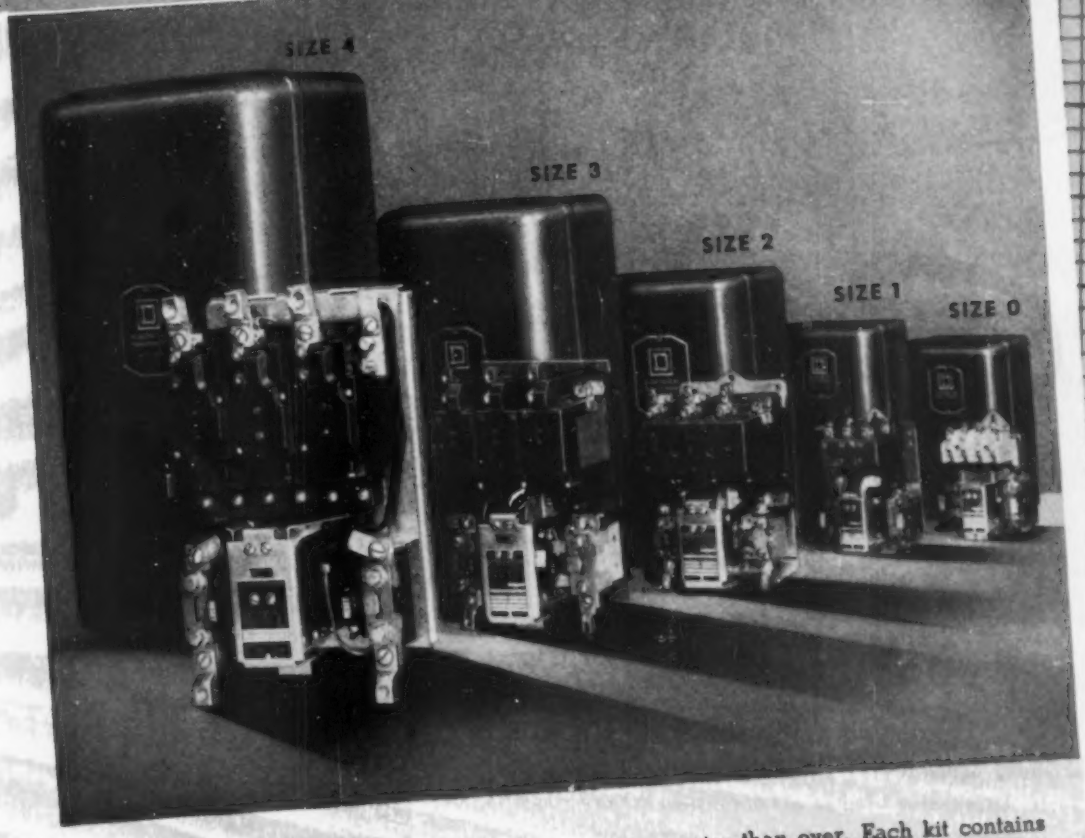
New coil holder simplifies coil change

All parts front-mounted for easy service and maintenance

SQUARE D COMPANY

1903 · 50 YEARS OF DESIGN LEADERSHIP · 1953

TO SQUARE D'S *Design* MOTOR CONTROL



● The highest degree of accessibility, flexibility and compactness—with no sacrifice of performance and long life. That's Square D balanced design—and you'll find it in every size Square D starter.

"Off-the-Shelf" Parts Kits, another Square D convenience feature, make normal maintenance easier than ever. Each kit contains parts to replace all load contacts and finger springs. Electrical interlocks also available in kit form.

• • •

Write for Bulletin 8536, Square D Company
4041 North Richards St., Milwaukee 12, Wisconsin

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

HEIM *Unibal* rod ends

Compensate for Misalignment . . . . .

The Heim Unibal Rod End solves most problems of transmitting motion at varying angles. The single ball principle of its construction reduces friction and lost motion in linkage applications; eliminates the effects of vibration; carries heavier loads; and corrects misalignment in all directions.

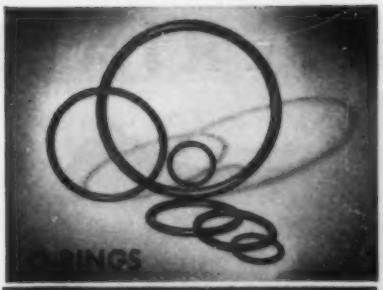
Perhaps you have a design problem which can be solved with Unibal Bearings or Rod Ends. Our engineering department is ready and willing to cooperate.

Write for complete catalog of Heim Unibal Bearings & Rod Ends

THE HEIM COMPANY
FAIRFIELD
CONNECTICUT

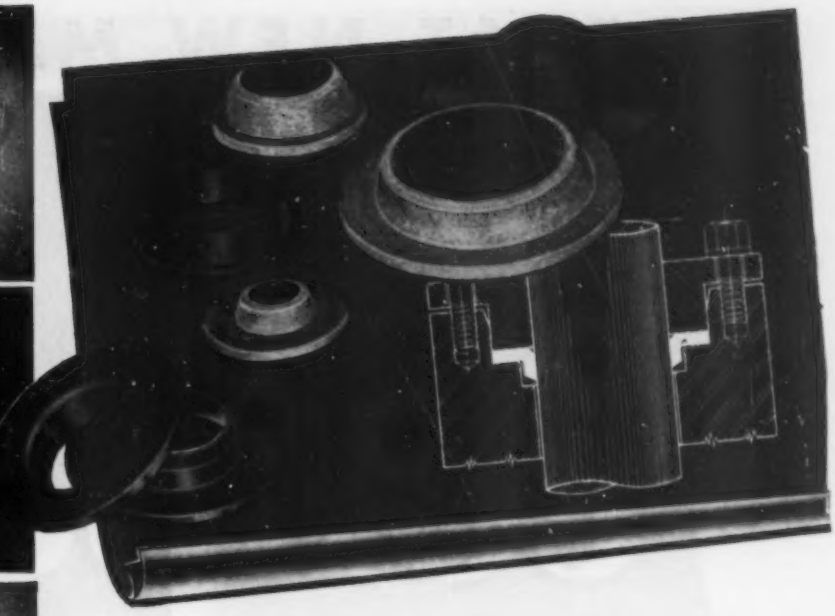
An Askania crank type cylinder mounted on a 24-inch butterfly valve.

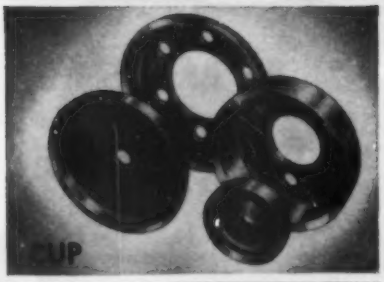
"Using Heim rod end bearings in this application compensates for any misalignment of the valve crank arm and the cylinder crank arm. It gives us a larger bearing surface than a conventional pin occupying the same space. It gives us a convenient way of enclosing the bearings in a boot, for cleanliness. By using right-hand and left-hand threads on opposite ends of the link, we have a turnbuckle arrangement for convenient and accurate link adjustment."

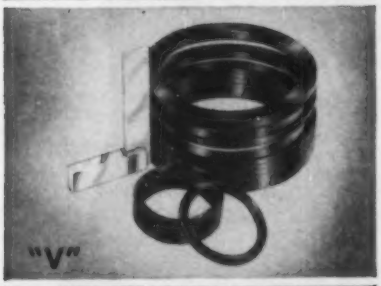


FLANGE PACKINGS

Made of leather or rubber. Installed in recess around a rotating or reciprocating shaft. Sealing lip and inner side wall form dynamic seal on shaft. Gland nose forms compression seal on shaft.







NOW . . . it's easier to order G&K-INTERNATIONAL Packings — always uniformly accurate

The Joint Industry Conference, together with packings manufacturers and government agencies, have set up dimensional standards for each packings type — identified by a Dash Number — making it easier for you to order, assuring greater accuracy and faster service.

You'll find all the code numbers in our new Packings Catalog and Manual — of course, we still require information as to mediums, pressures, temperatures.

But because G&K-International follows the standard specifications — we can save time for you. Our engineers and chemists are also ready to study your non-standard requirements and recommend special types of packings to function in hard-to-do jobs.

Call on G&K-International for *all* your packings needs.

Replacement Packings

Modern JIC standards are also simplifying the specs for replacement packings. However, thousands of presses and other hydraulic equipment require leather packings in the larger or non-standard sizes. Over the past 50 years we have produced many thousands of these packings, including leather U's and "crimps" up to 6 feet in diameter.

Consult G&K-International for your replacement needs. You'll find the answer here.

New Packings Catalog

A comprehensive Catalog and Manual covering all up-to-date packings standards you ought to know about for your packings and oil seal needs. We want you to have a copy. Tell us where to send it!

G&K GRATON AND KNIGHT INTERNATIONAL

GRATON & KNIGHT COMPANY
Established 1851
P-6 **Worcester 4, Massachusetts**

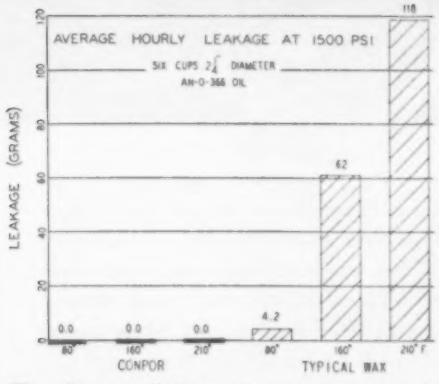
INTERNATIONAL PACKINGS CORPORATION
Graton & Knight Company Affiliate
Bristol, New Hampshire

A GREAT NEW MATERIAL!

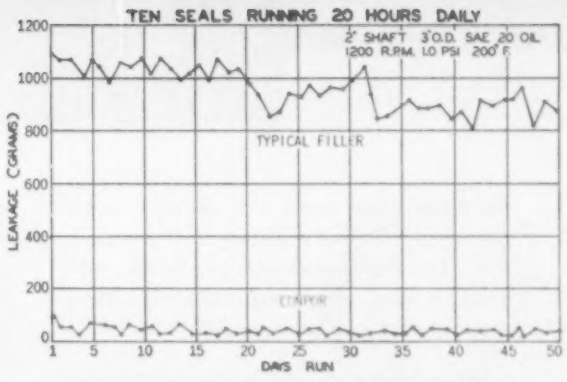
conpor is the first of its kind

Conpor is the first material for oil seals and packings that provides *all* the advantages of leather and yet gives complete porosity control. It has flexibility, strength, stability, oil and solvent resistance, yet permits lubrication through the seal or packing member—with a controlled porosity range of from zero to 100%. *Conpor* is the result of a six-year development program. Now, by impregnating specially tanned C/R Sirvis Leathers with Thiokol liquid polymers, under controlled conditions, Chicago Rawhide offers a full range of *Conpor* sealing and packing materials to meet a wide variety of applications.

conpor kills undesirable leakage



The efficiency of *Conpor* impregnations under high pressure, as compared to ordinary wax fillers, is evidenced in the left chart; the 1000-hour test, at



right, shows consistency of leakage protection in *Conpor* shaft sealing. The temperature range of *Conpor* efficiency is from 250° F. to —70° F.

conpor offers you these advantages

- *Complete leakage control in lubricant, solvent, hydraulic, and pneumatic applications.*
- *A stable material, with broad resistance factors, that eliminates all the faults of previous fillers.*
- *Many times the service life of previous leather sealing and packing materials.*
- *Better lubrication control at points of friction.*
- *Less shaft scoring from oil seals.*
- *Designing for lower torque and less waste of horsepower.*
- *Reduced original costs in most cases, and always greater economy in service.*

conpor information is ready for you

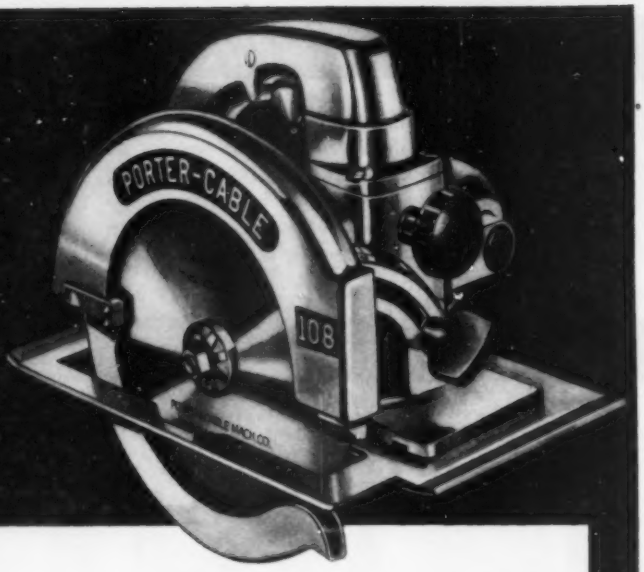
Send for this! "*Report on Conpor*" *gives you all the basic information on this vital new material. In addition our engineering service will be glad to work with you in developing Conpor sealing products for your own applications.*

Please write to:
MR. A. S. BERENS
CHICAGO RAWHIDE MFG. CO.
960 North State • Elgin, Illinois

75 C/R
conpor
CONTROLLED POROSITY
SIRVIS MECHANICAL LEATHER

conpor IS MADE EXCLUSIVELY BY CHICAGO RAWHIDE MANUFACTURING COMPANY

DIE CASTINGS have Lighter Weight Greater Strength



CASE HISTORIES FROM MT. VERNON FILES

This Porter-Cable Model 108 portable electric power saw, designed especially to fit the needs of builders, maintenance men, and farmers, must be light in weight, strong, and have exact balance to permit convenient one-hand use.

That's why The Porter-Cable Machine Company uses aluminum die castings made by the Mount Vernon Die Casting Corporation. They're sold on the important advantages of their lighter weight, greater strength.

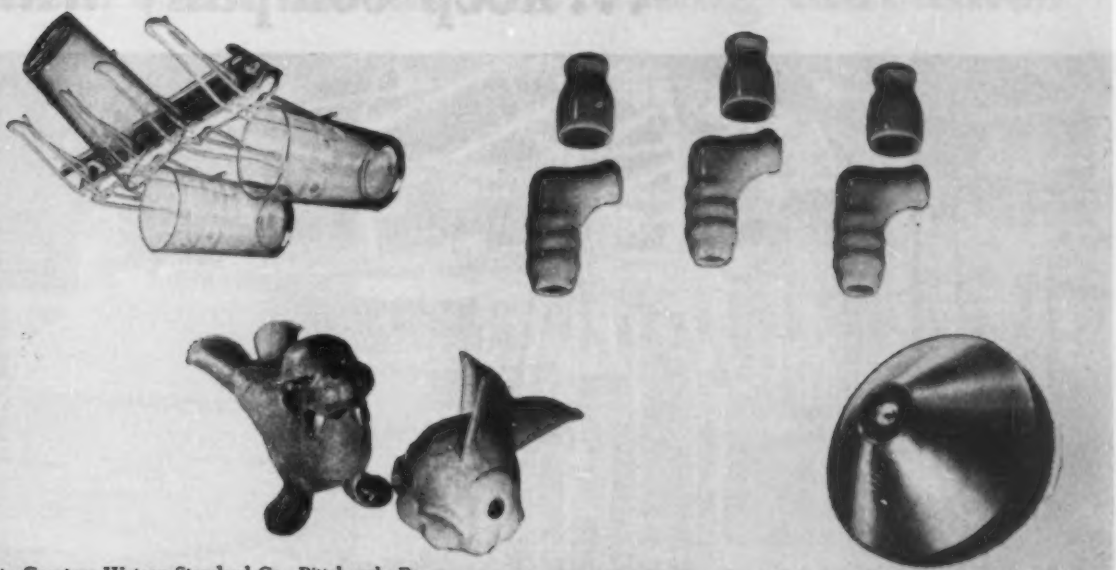
In fact, Porter-Cable uses Mount Vernon castings for many of their portable tools, because they find that die casting enables them to hold weight down to a minimum, lowers cost of tooling, provides high quality castings at reduced costs, speeds production schedules.

With Porter-Cable, Mount Vernon die castings prove themselves in action. Perhaps you, too, have products that require combined light weight and strength, or some of the other many advantages die casting can bring you. Let us go to work for you. Send us specifications or consult our engineering department.

MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK

Speed Production, Stretch Performance

...with this Strong, Flexible Plastic



Data Courtesy Watson-Standard Co., Pittsburgh, Pa.

COLORFUL BATHTUB TOYS are formed by rotating plastisols in molds in an oven. Plastisol clings evenly to mold's inner wall and fuses there. Color is applied after removal from mold. Toys are hollow, flexible, buoyant, safe.

TANK BALL made of plastisols outlasts one of conventional material three to one. Like toys, it also is produced by rotational molding, but is removed from oven before entirely curing, so excess plastisol can settle at one end to give extra weight.

DIP-COATED with plastisols, the wire frame of this rack has a soft cushiony covering that protects glassware from metal. Coating stays resilient, is easy to clean, withstands abrasion, will not crack or peel. Rack is made by the Gray Company of Elgin, Ill.

CAPS for spark plugs and distributor wires are molded of plastisols. They fit tightly, sealing out dirt and moisture. They won't dry out or swell, are resistant to gas, oil, heat, aging, have low dielectric properties. They are made by the Endlaco Co., Milwaukee, Wis.

The variety of articles in this collection gives an idea of the range of uses for plastisols based on BAKELITE Vinyl Dispersion Resins.

Whatever the job, plastisols offer long service life under the harshest treatment—abrasion, engine heat, water immersion, oils, soaps and chemicals. Their dependability is proven by the retention of their basic properties of softness and resiliency. They resist distortion, cracking, and wear. Their surfaces stay smooth, colors fresh.

Simpler manufacturing techniques are another big advantage of plastisols made with BAKELITE Vinyl Dispersion Resins. These fluid materials require little or no pressure, can be used for molding, pouring, coating, and dipping. Baking at low temperatures quickly cures them into a tough, pliable plastic.

This easy-forming characteristic of BAKELITE Vinyl Dispersion Resins makes them useful for intricate, delicate operations, where high-pressure molding would be impractical. They have good electrical properties. Surfaces can be glossy or flat in finish.

For further examples, write Dept. RW-10 for the informative booklet, "VINYLITE Organosol and Plastisol Dispersion Resins."

BAKELITE
TRADE-MARK
VINYL RESINS

TRADE MARK
BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.

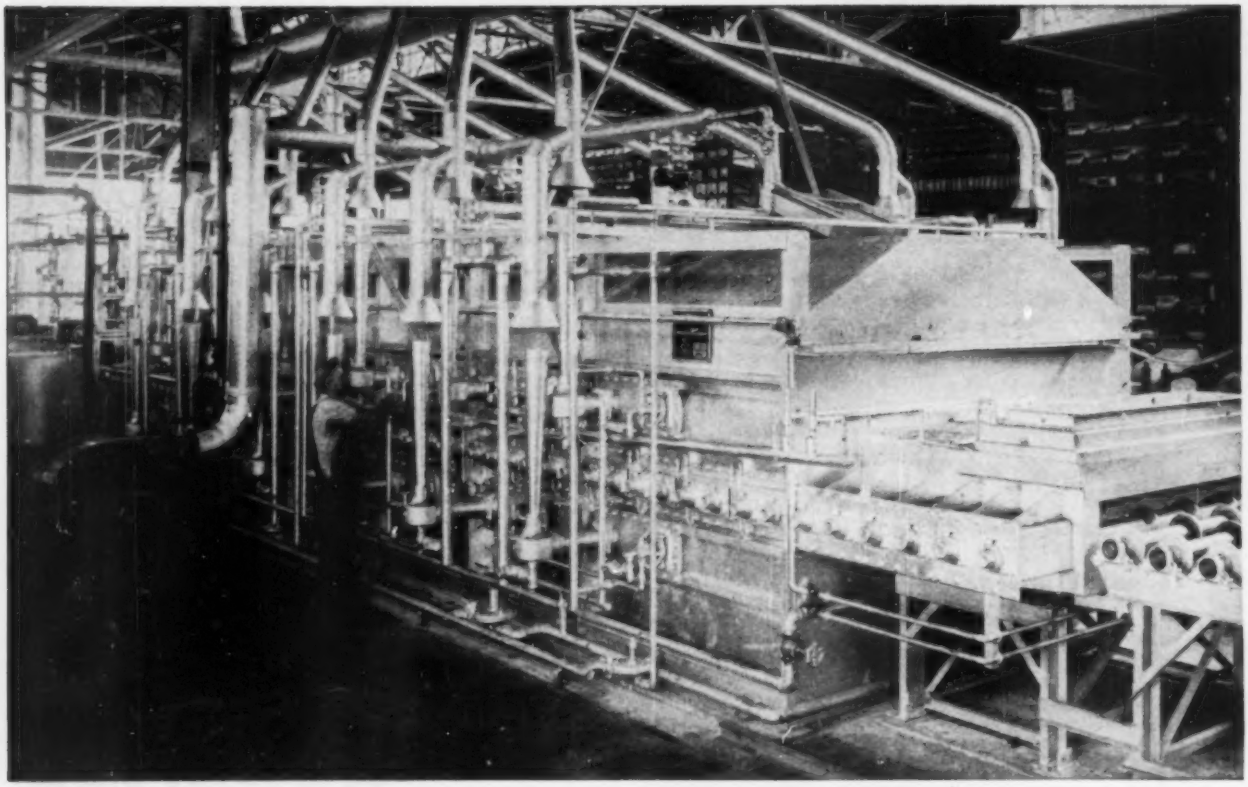
BOOK JACKET shows title through its back of transparent film of BAKELITE Polyethylene laminated to paper covers. It's strong, flexible, resistant to handling, perspiration, dirt. Made by Bro-Dart Industries, Newark 5, N. J.

BRISTLES on this sponge mop are BAKELITE Styrene Plastic monofilaments that retain stiffness, won't curl, withstand soaps and detergents. Dirt can't penetrate. Made by Empire Brushes, Inc., Port Chester, N. Y.

SPACE SCALE for calculating areas on charts is printed on BAKELITE Rigid Vinyl Sheet, which resists handling, oil, dirt. Made by Sillcocks-Miller Co., W. Maplewood, N. J. for New Era Products, New York, N. Y.

LINK-BELT ball and

...keep company with

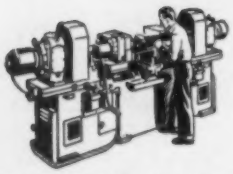


YOU can always count on top performance when you specify Link-Belt precision bearings. For Link-Belt's Sealed-Housing feature assures longer bearing life plus extended lubricating schedules. And Link-Belt alone offers this vital feature in *both* ball and roller models.

With this exclusive advantage, all moving surfaces are completely enclosed and lubricated from a large, common reservoir. Grease stays in, dirt stays out . . . and wear is minimized even under grueling operating conditions.

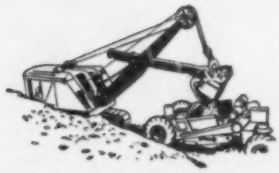
Link-Belt's experienced engineers will be glad to help you in your bearing application problems . . . with no obligation, of course. Or you may get full information from Data Book 2550.

LINK-BELT ball and roller bearings

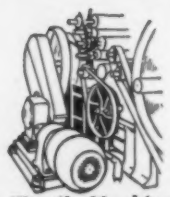


Metal Working Machinery

Farm Machinery



Construction Equipment



Textile Machines

roller bearings

America's hardest-working machines

Automotive parts are annealed by one of the big auto-makers in this continuous roller hearth radiant tube-fired furnace built by Surface Combustion Corp., Toledo, Ohio. As on many of their other furnaces, Link-Belt ball and roller bearing pillow blocks and flanged blocks are used to withstand the demands of high temperatures and continuous operation.

Universally aligning. Capacity for radial and thrust loads.
Wide inner ring distributes load over large shaft area.
Lubrication fitting with pressure relief feature prevents excessive grease pressure.
Self-aligning seals effectively keep grease in and dirt out, regardless of alignment.
Spring-locking collar with set-screw clamps bearing firmly on shaft.
Lubricant passes freely into large reservoir to lubricate moving surfaces.
Easily installed by slipping bearing onto shaft and clamping inner ring by tightening two set-screws in spring locking collar.
Sturdy, compact cast housing requires minimum support space, can be positioned on the side of a machine.

Cutaway of Series 200 Ball Bearing Flanged Block — part of Link-Belt's line of Pillow Blocks, Flanged, Flanged Cartridge, Cartridge, Hanger, Take-up Blocks and unmounted Bearings.

LINK-BELT

BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Sidney; South Africa, Springs. Representatives Throughout the World.

13098A

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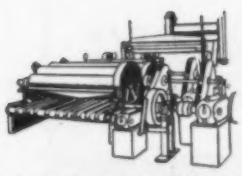
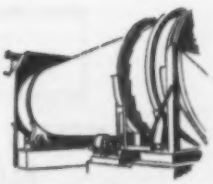
smooth the path of power for all industry



Pulp & Paper Machinery

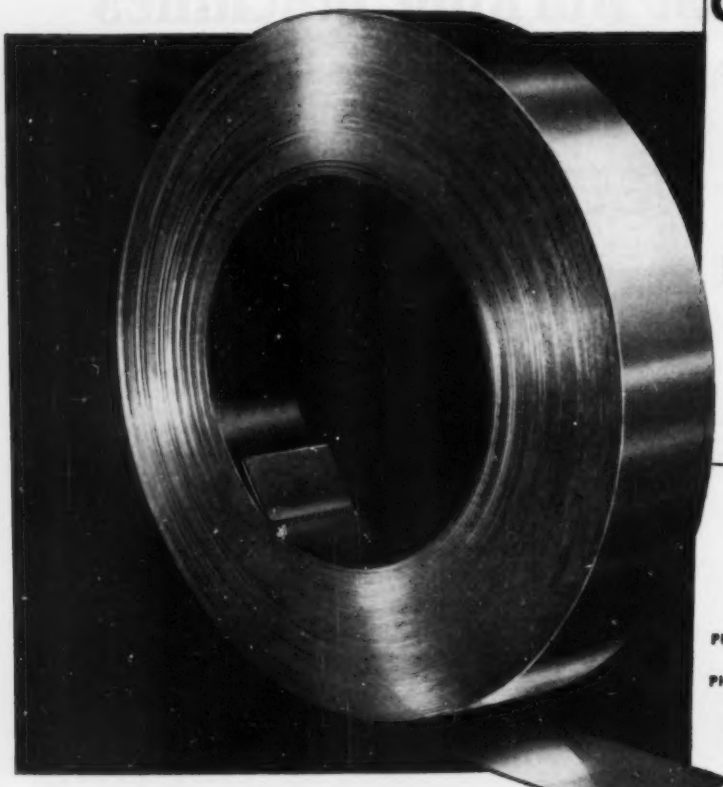
Materials Handling Equipment

Oil Field Equipment



Processing Equipment

NEED SPRING MATERIALS WITH HIGH CONDUCTIVITY?

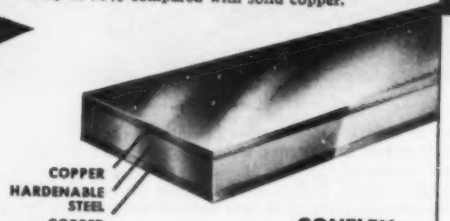


General Plate Composite Metals

BRONCO, CONFLEX and SILVER-CLAD PHOSPHOR BRONZE meet all requirements

BRONCO

The phosphor bronze makes an excellent spring member. The copper increases conductivity. BRONCO 25/50/25 provides an electrical conductivity of 55% compared with solid copper.



CONFLEX

Copper clad on one or both sides of hardenable steel in any thickness ratio. Its primary advantage is *low cost*. The hardenable steel provides greater stiffness than copper alloys.

SILVER-CLAD PHOSPHOR BRONZE

Silver clad on one side provides an exceptionally good electrical contact surface.... Offers higher electrical and thermal conductivity. Also available as silver-clad beryllium copper.

These General Plate composite metals, made by metallurgically bonding one metal to another, provide an economical solution to your electrical spring problems.

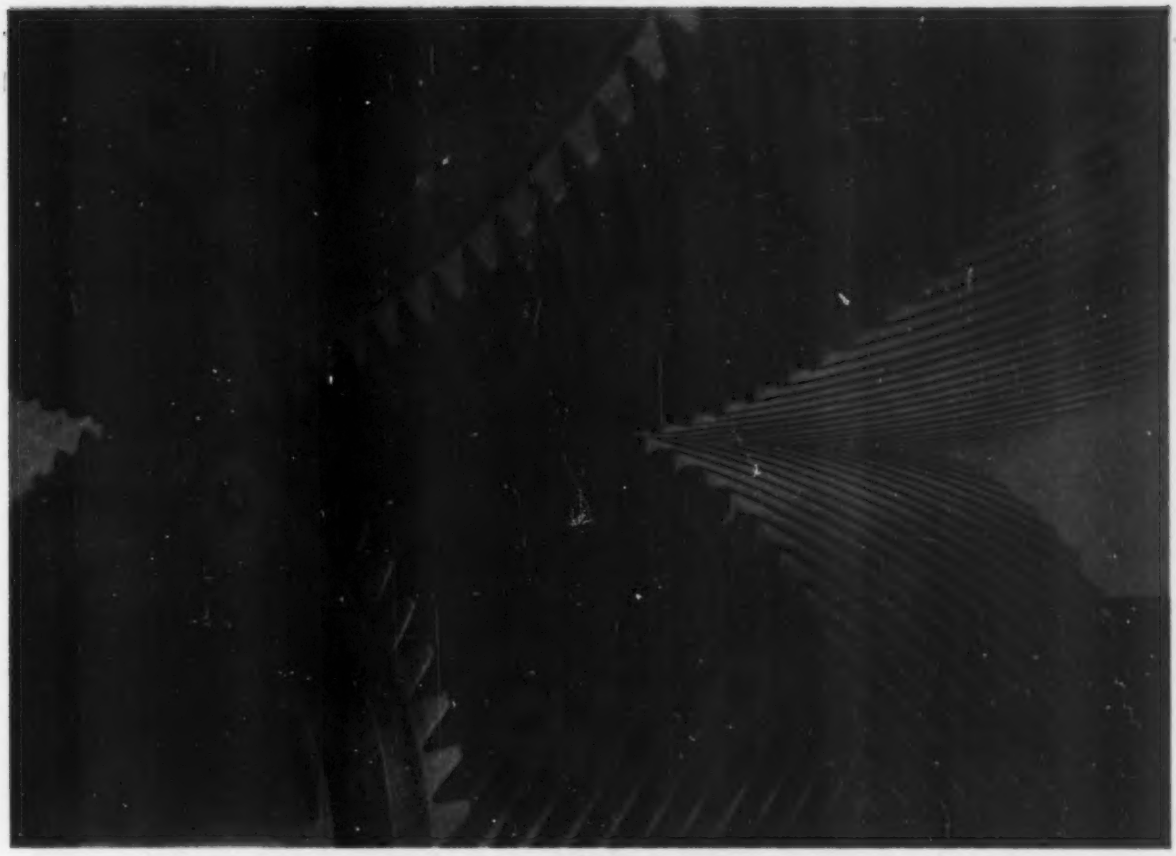
Each has specific physical and mechanical properties that make it better suited for certain applications. For instance, Bronco permits miniaturization, because you can reduce spring size without sacrificing conductivity. Conflex enables you to make fuse chips, flat springs, and electrical connectors at a lower cost.

No matter what your problem, it will pay you to consult with General Plate. Their vast experience in bonding any combination of malleable metals can overcome your problems ... often reduce costs.

General Plate products include ... precious metals clad to base metals, base metals clad to base metals, thin-gauge rolling, composite contacts, buttons and rivets, Truflex® thermostat metals, Alcupiate®, platinum fabrication and refining, #720 manganese age-hardenable alloy. Write for complete information and Catalog PR700 today.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
111 FOREST STREET, ATTLEBORO, MASS.



These gears INHERIT precision

The precision in Farrel® herringbone gears is passed on from the machine on which the gears are made — the Farrel-Sykes Gear Generator.

The accuracy inherent in the operating principle of the machine—"*precision generation*"—gives the gears extremely accurate tooth spacing, profile and helix angle. Because of this, you can be sure that Farrel herringbone gears will operate smoothly, quietly and efficiently over a long service life.

These precision-generated gears are made in any size from ¼" to 20' 0" diameter, for any power capacity and speed. Also available are straight tooth and single helical gears in sizes up to 20 feet diameter, and large internal gears with either spur or helical teeth.

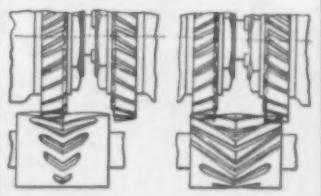
Farrel engineers will be glad to assist you in working out unusual gear problems. Write for further information about any of the types of high-precision gears mentioned above.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Memphis, Minneapolis, Portland (Oregon), Los Angeles, Salt Lake City, Tulsa, Houston, New Orleans

Farrel-Birmingham®

FB-863

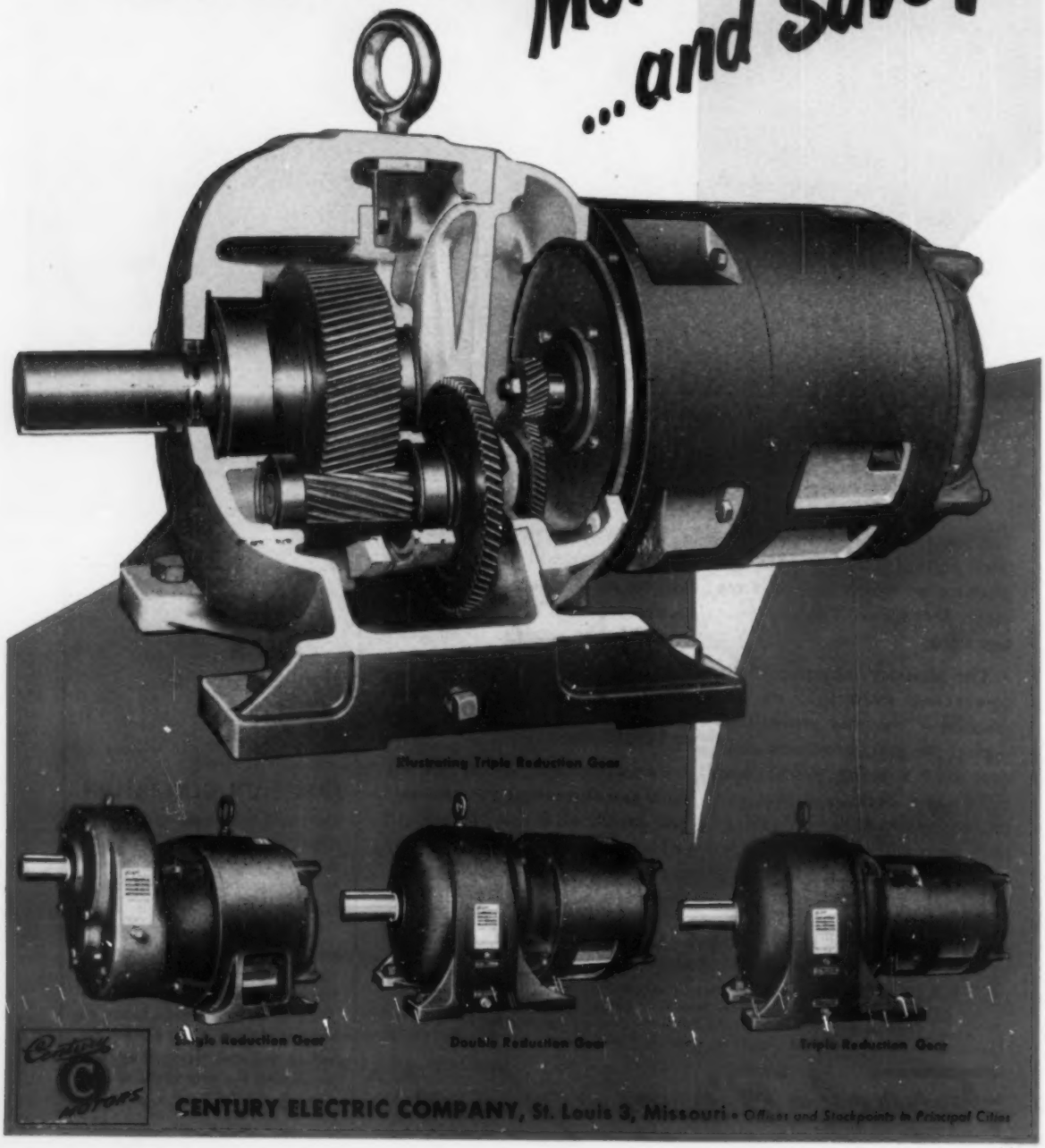


PRECISION GENERATION

The Farrel-Sykes gear generator is a gear-shaping machine having two cutters, mounted on a single reciprocating carriage, with their cutting faces opposed.

The cutters reciprocate, one cutting when movement is in one direction and the other when the movement is reversed. Each ends its stroke at the center of the blank. As they cut they twist to generate the helices and also slowly revolve in unison with the gear blank to generate the tooth contours precisely.

NOW Simplify Your Motor Drives ...and Save!



Century Motors

CENTURY ELECTRIC COMPANY, St. Louis 3, Missouri • Offices and Stockpoints in Principal Cities

Here's BUILT-IN SPEED TO FIT YOUR NEED

with the complete, new line of

Century Gearmotors

equipped with **Duti-Rated Precision Gearing**

Think of how you can improve power transmissions with more *compact drives* to save valuable space... *simpler drives* to minimize supplementary transmission ...*safer drives* with fewer exposed moving parts... *improved appearance*... *smoother, more efficient operation*. *easier cleaning and maintenance.*

All these advantages and economies are yours, with rugged Century GEARMOTORS providing built-in speed to match the operating speed of your equipment. The new Century line offers a wider-than-ever choice of:

BUILT-IN SPEED... in single, double and triple reduction gear ratios... with A.G.M.A. Class I, II and III service to match load conditions.

CURRENT AND OPERATING CHARACTERISTICS ... single phase, polyphase or D.C. motors, equipped for single speed, multi-speed or variable speed control... with normal torque, high torque or high torque/high slip characteristics to suit load requirements.

FRAME PROTECTION . . . for practically every atmospheric condition, indoors and outdoors:

- **Open type for normal conditions**
- ***Splash Proof* for out-of-doors, or where equipment is washed down**
- ***Totally Enclosed Fan Cooled* for atmospheres containing dust, grit or corrosive matter**
- ***Explosion Proof*, Underwriters' Approved**

HORSEPOWER... 1 to 15 h.p. with Duti-Rated Precision Gearing... and, in addition, Century's already well-known line of fractional horsepower gearmotors from ⅛ to ¾ h.p. Larger ratings can be furnished if required.

For Fast Selection **of the right Century GEARMOTOR with built-in speed to fit your own specific needs...**

USE THIS HANDY COUPON to send for free price and data sheets showing the new, wide range of gear speeds and A.G.M.A. gear classes for various service conditions...

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CENTURY ELECTRIC CO., 1806 Pine St., St. Louis 3, Mo.

Please send Bulletin

☐ Bulletin 4-1p21 ⅛ to ¾ H.P.

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Diversatility rides again

in the [new] COMPLETE line of SPEED KING Valvair Solenoid Pilot Operated Control Valves

Valvair Speed Kings are small, light in weight, with a speed of 600 cycles per minute, and proven capable of 20,000,000 cycles and up.

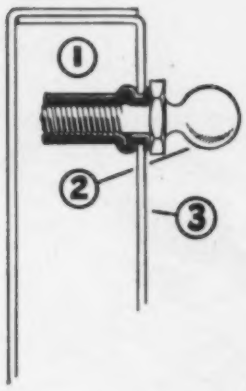
The New Valvair Speed King line is complete — 3-way, 4-way, and 4-way-5-port (2-pressure), foot-mounted or sub-base manifold mounted; pipe sizes — ¼", ⅜", ½", ¾", 1". *Complete* — to fit almost innumerable applications. A precedent-breaker in size, weight, speed and endurance. Only one moving part. Non-corrosive materials throughout. Solenoid and pilot valve parts are totally enclosed, but easily accessible. *Get all the facts!*

VALVAIR CORPORATION *Affiliate: Sinclair-Collins Valve Company*
961 BEARDSLEY AVE., AKRON 11, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

Rely Upon Valvair DIVERSATILITY

Ask for Bulletin "11-PE".

One B. F. Goodrich RIVNUT solves 3 fastening problems!

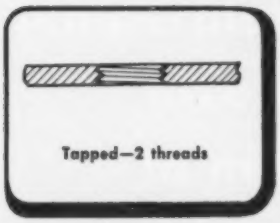


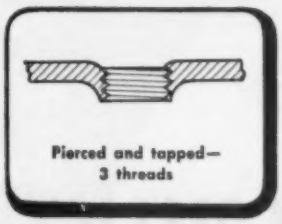
A RIVET WAS NEEDED for doors of metal cabinets that 1) could be installed from one side only, 2) would serve as a nut plate for a knob attachment, and 3) could be installed after enameling. A B. F. Goodrich Rivnut proved the perfect answer.

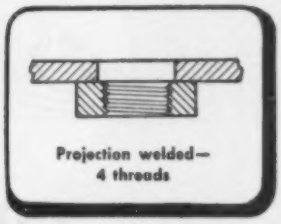
A flat-head Rivnut is inserted in the sheet metal door. Working from one side, one man can upset Rivnut in 2 seconds with easy-to-operate heading tool. Bulge formed in Rivnut shank grips the metal tightly. The knob of the catch is then threaded into the clean, still-intact Rivnut threads. Rivnuts are installed after enameling without marring the finish.

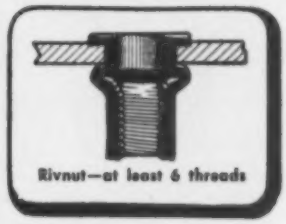
This simple solution saved many man-hours on the job. If you have a fastening problem, why not put it up to Rivnut engineers? Write to The B. F. Goodrich Company, Dept. PE-113, Akron, Ohio.

Compare these 4 methods of putting screw threads in thin sheet metal



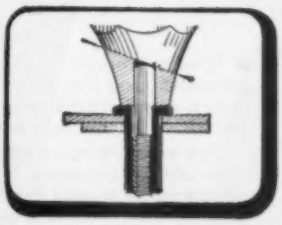




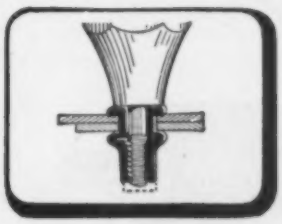


Rivnuts provide at least 6 clean threads in one simple operation!

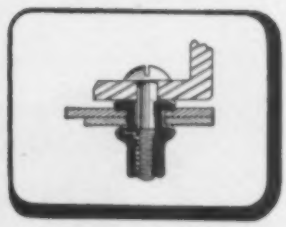
1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.



4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

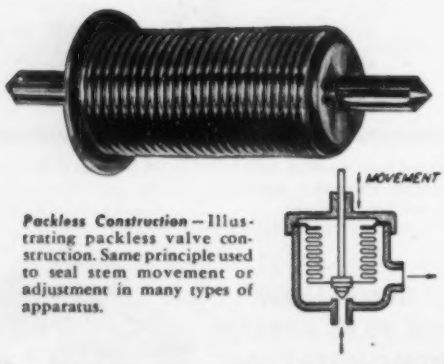
B.F.Goodrich RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to The B. F. Goodrich Company, Department PE-113, Akron, Ohio.

A SPECIALIST DOES IT BEST!



Packless Construction — Illustrating packless valve construction. Same principle used to seal stem movement or adjustment in many types of apparatus.

● If your products or product plans require bellows assemblies, you can get real help from specialists at Fulton Sylphon or Bridgeport Thermostat. They've specialized in this field for over half-a-century.

This valuable experience can help you in many ways. Skilled personnel and ample production facilities are ready to take care of your bellows assemblies needs quickly and accurately.

And our specialists are equally helpful in working with you to design and produce bellows assemblies specifically adapted to your requirements. On all counts you save time, production worries and expense.

Sylphon and Bridgeport bellows assemblies are used in many ways—as flexible connectors, for thermostatic devices, pressure controls, hydraulic mechanisms, expansion joints and other units. Wide range of metals and sizes. Write for information. Ask for helpful, idea-filled Catalog UP-1400.

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TEMPERATURE CONTROLS • BELLOWS ASSEMBLIES • BELLOWS DEVICES

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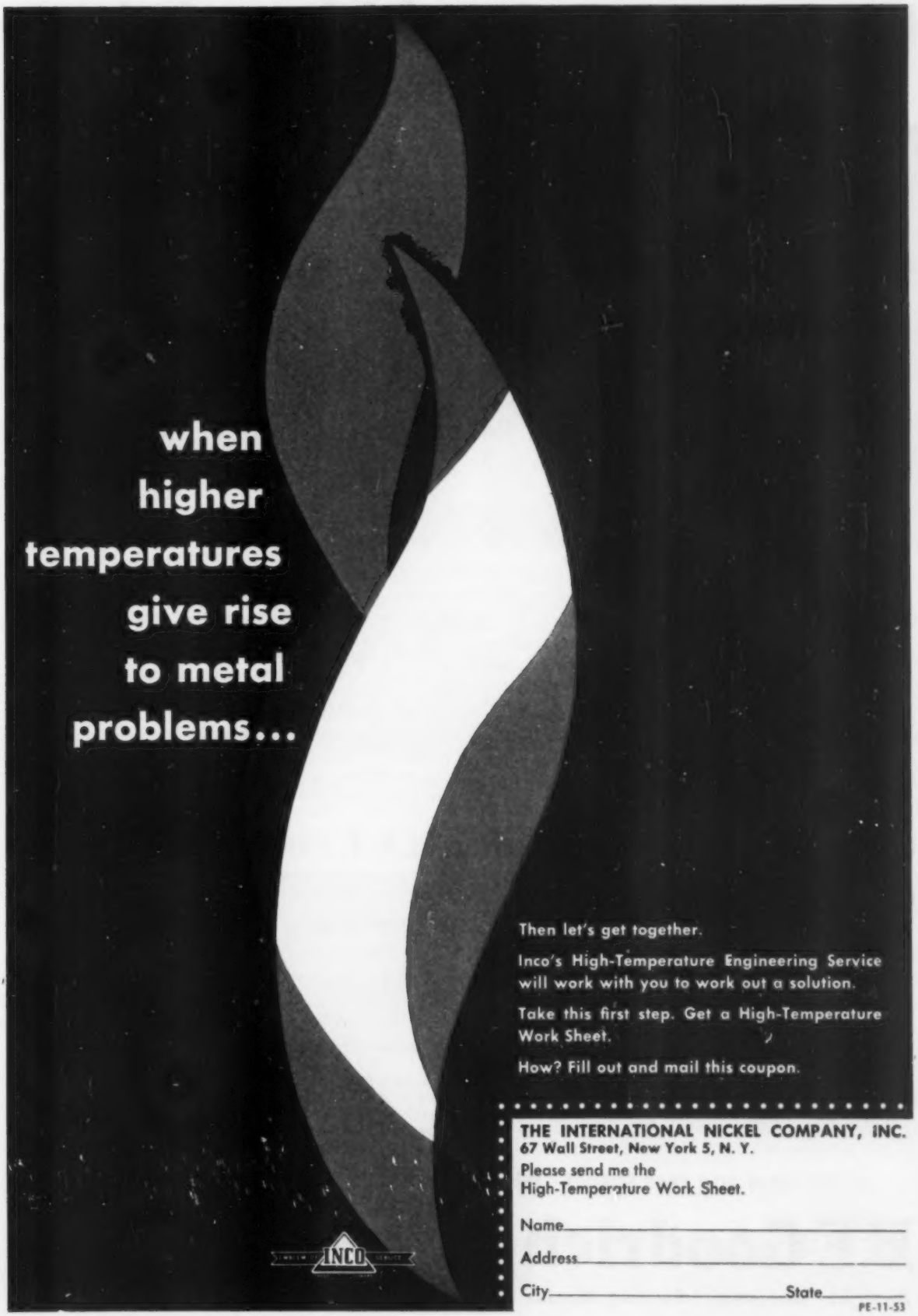

Then let's get together.

Inco's High-Temperature Engineering Service will work with you to work out a solution.

Take this first step. Get a High-Temperature Work Sheet.

How? Fill out and mail this coupon.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

Please send me the
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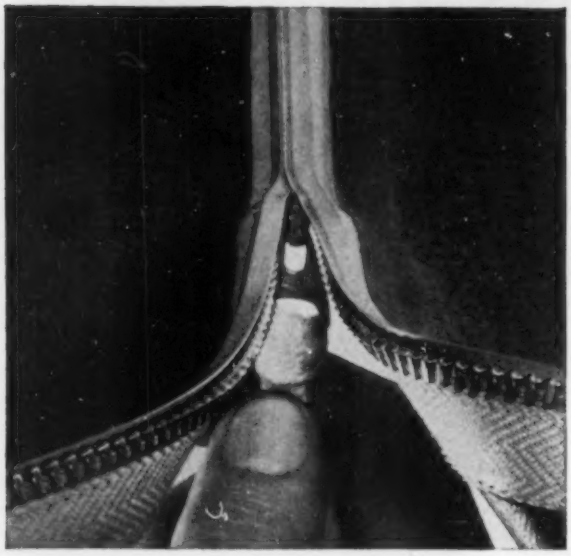
PE-11-53

How new B. F. Goodrich seal shuts up hot air, opens with a zip



THE NEW B. F. Goodrich Sealing Zipper gives an airtight, watertight seal yet zips open in seconds. It's solving many tough sealing problems for design engineers.

Here's how the BFG Sealing Zipper works: Molded rubber lips overlap with hairline precision to seal tight, even without pressure. The greater the pressure, the tighter the seal. Only limit to the pressure is the structural strength of the zipper itself. The standard zipper opens or shuts in a hurry. Can go around curves and corners. Can be sewn or cemented to metal, wood, glass. Can be made to match any color. Rubber can be compounded to resist weather, oils, gasoline, chemicals, other conditions.

In the application right above, the BFG Sealing Zipper is used to keep hot air shut up in an airplane duct. It simply unzips to make duct sections easily removable, speeding maintenance. Proved in dozens of other aviation and transportation applications, the B. F. Goodrich Sealing Zipper is ideal for any use that combines a need for an airtight, watertight barrier with ease of opening. Opportunities in industrial and consumer fields are unlimited.

If you think the BFG Sealing Zipper can solve a design problem for you, consult our zipper engineers. Write, sending blueprints and specifications, to The B. F. Goodrich Company, Dept. A-81, Akron, Ohio.

Four tough sealing problems solved by B. F. Goodrich Sealing Zipper

ON RUBBERIZED CURTAIN, B. F. Goodrich Sealing Zipper keeps fumes from airplane engines out of forward compartment. Yet it lets men in and out in a hurry.

ON LIFE RAFT STORAGE CASES, Sealing Zipper keeps sea water and oil from seeping inside and damaging contents, zips open instantly in emergencies.

ON REAR WINDOWS OF AUTO CONVERTIBLES, BFG Sealing Zipper keeps moisture from staining and mildewing inside fabric. Colors match inside and out.

ON CARRYING CASES for cameras and instruments, BFG Sealing Zipper keeps out moisture, light, dust. Cases can be opened quickly and easily.

SEND NOW FOR FREE FOLDER

B.F.Goodrich

Airtight, Watertight Sealing Zipper

Explains with cross-section drawing how B. F. Goodrich Sealing Zipper works. Gives design advantages, successful case histories, suggested uses. Shows available zipper styles. Write to The B. F. Goodrich Company, Dept. A-81, Akron, Ohio.

Proved! **by thousands of hours...on thousands of machines!**

ALEMITE OIL-MIST LUBRICATION

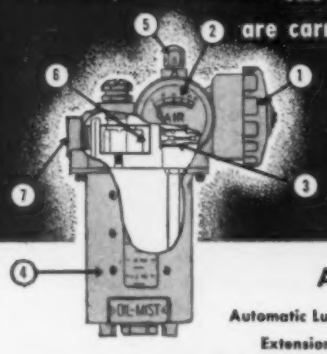
the most efficient lubricating system ever devised!

1. MULTIPLIES Bearing Life!
2. CUTS Product Spoilage!
3. BOOSTS Machine Output!

Millions of actual machine hours on countless installations prove Alemite Oil-Mist is the most efficient automatic lubrication system you can specify. Easy to incorporate into new projects . . . just as easy to use in modifying existing designs! Oil-Mist can bring impressive savings in man-hours, bearing life, lubricant, decreased product spoilage . . . can save its cost over and over again!

This is an amazingly simple system of lubrication, which applies a clean, cool, constant and uniform film of oil wherever it is needed—to groups of bearings, slides, chains, gears—to any moving part. Oil-Mist is unique. The lubricator has no moving parts, operates on compressed air, and is completely automatic—proved completely foolproof.

HOW IT WORKS: **The Oil-Mist Lubricator atomizes oil into microscopic particles which are carried in the air stream and distributed through tubing to bearings**

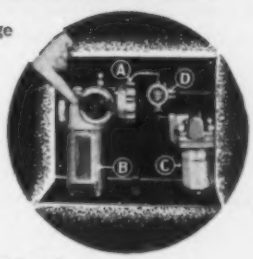


Oil-Mist airborne lubrication is accomplished this way: Compressed air entering the unit passes through air regulator (1) and air gauge (2). As this air passes through venturi (3) it draws oil from reservoir (4). Oil flow is set by knob (5). The mixture of air and oil from the venturi is thrust against baffle (6). Only the most minute, lighter-than-air particles are blown through outlet (7) into delivery line to lubricate bearings.

Alemite Oil-Mist offers all these lubrication advantages

Automatic Lubrication • Continuous Lubrication • Eliminates Guesswork • Cuts Oil Consumption up to 90%
Extension of Bearing Life • Stops Oil Drippage • Reduction of Bearing Temperatures • Greater Safety
Reduction in Number of Lubricants • Protection from Contamination • Elimination of "Down-Time" • Manpower Savings

LUBRICATOR SPECIFICATIONS:



- Oil-Mist outlet ½" fem. p.t. Air gauge registers to 50 psi. Operating air pressure—5 to 20 psi.
- Air regulator **(A)** reduces from pressures up to 200 psi. Normal air consumption—.7 to 1.2 cfm.
- Range of oils handled—to 1,000 sec. (S.U.V.) @ 100°F.
- Oil reservoir **(B)** capacity 12 oz. (approximately 1 week supply). Intake filter screen—70 mesh. Fill plug—⅜".
- Material—die cast aluminum body with nylon plastic window.
- Baffle-type water separator **(C)**—automatic self-dumping. Requires no manual attention—no filter elements to replace. Air inlet ¼" fem. p.t.
- Solenoid Control **(D)** starts system automatically when machine starts—foolproof.

delivers oil to bearings *3ways*

1. Oil-Mist as Such. Most commonly applied to any type of anti-friction bearing—ball, roller or needle.

2. Oil in Spray Form. For open and enclosed gears and chains. Nozzle partially condenses mist so that it can be directed on to a concentrated area.

3. Oil-Mist Condensed. For plain bearings, slides, ways, vees, cams and rollers. In these applications, condensing fittings convert oil-mist to liquid oil.

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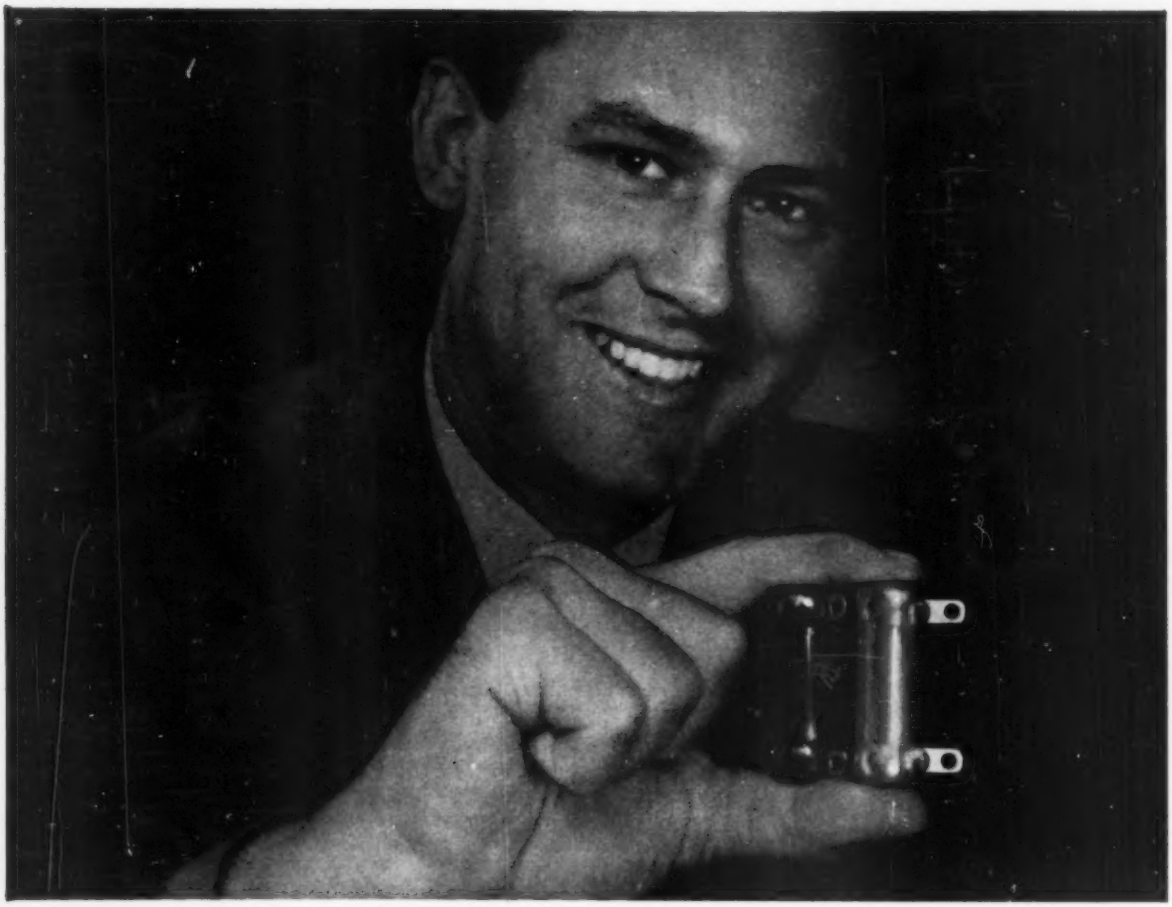
Write Today! **This Oil-Mist Catalog and Engineering Data Book is FREE for the asking. Write now for your copy. Alemite, Dpt. T-113 1850 Diversey Parkway, Chicago 14, Illinois.**

Alemite OIL-MIST Lubrication

"O.K. But what's your price for performance?"



Here's a purchasing agent buying resistors on a price basis. But doing it the *right* way.

Some day we may even be able to quote resistor prices in terms of performance—so many cents per thousand hours of trouble-free operation. Then we'll be able to tell you exactly how much *less* Ward Leonard resistors really cost than the so-called "bargain" resistors now on the market.

But until then, remember, it's *performance* you pay for when you're buying resistors. There's a lot more than just a few cents difference in the performance you'll get from the two resistors above.

The one made by Ward Leonard will perform at its rated value for the life of the product it goes into. There's a chance the so-called "bargain" resistor will too. But you can't afford to take *any* chances on your product's failure—even once out of a hundred times. Not when you consider the actual cost of such failure, figured in terms of returned merchandise, replacement cost, customer and dealer dissatisfaction.

That's why, even on a price basis, the accuracy, dependability and uniformity of Ward Leonard resistors make them far better buys than any of the questionable bargains you'll find on the market. Send for *new* Resistor Catalog No. 15. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y.

3•18

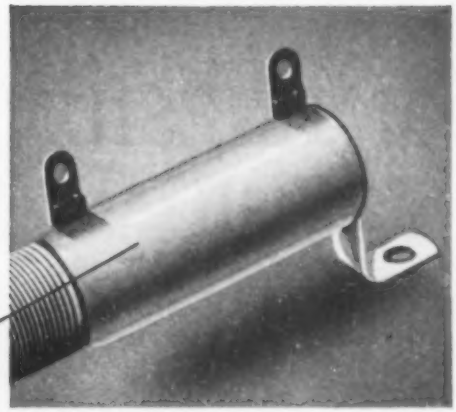
WARD LEONARD

WARD LEONARD ELECTRIC COMPANY

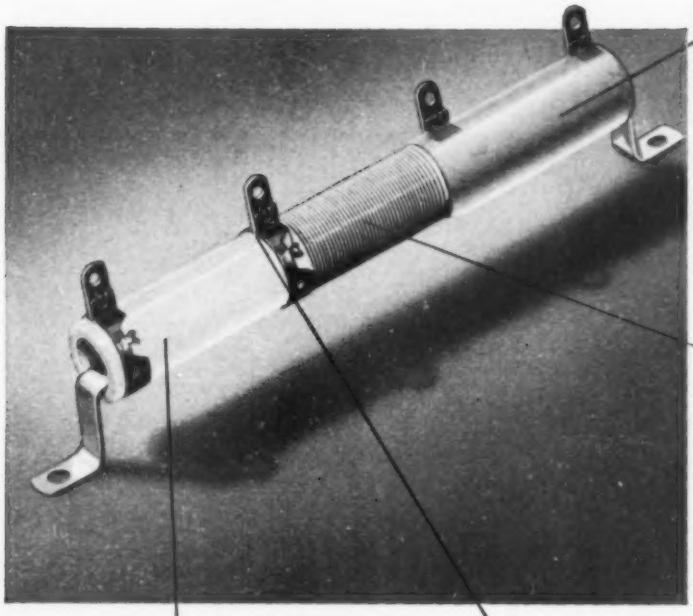
MOUNT VERNON, NEW YORK

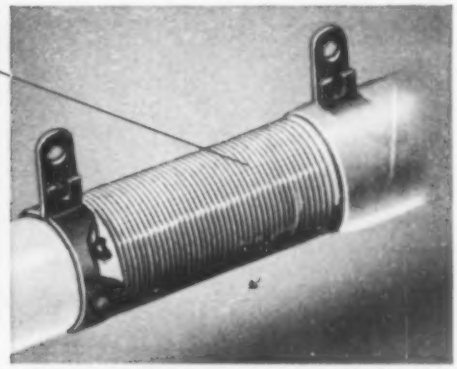
Result-Engineered Controls Since 1892

This check list shows you how to get the most for your money in terms of resistor performance

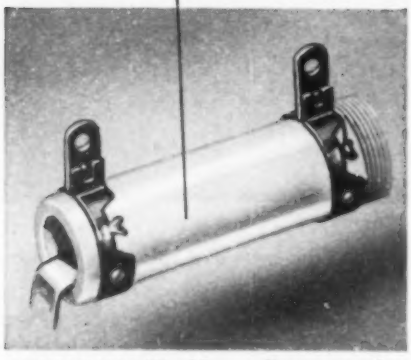


COATING. Vitrohm enamel coating of all Ward Leonard resistors provides a complete hermetic seal highly resistant to shock, high humidity, extreme temperatures, acids, alkalies, and electrolysis. Unlike most resistor manufacturers, we manufacture our own vitreous enamel.

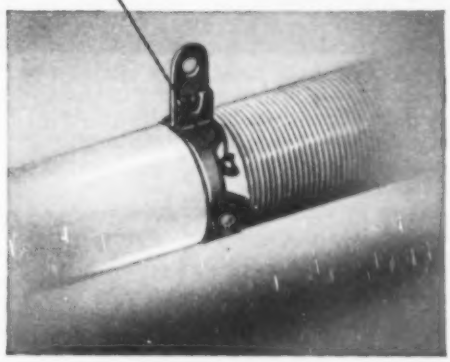




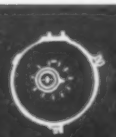
RESISTANCE WIRE. The resistance wire is drawn to Ward Leonard's own specifications for each particular resistor type. It is capable of withstanding heavy overloads, has a uniformly low coefficient of resistivity. Many of the "bargain" resistors are wound with resistance wire of ordinary grade.



RESISTOR CORE. Ward Leonard's own manufactured cores upon which the resistance elements are wound consist of a perfectly cylindrical ceramic body of high density, low porosity, and high dielectric strength, with a thermal coefficient of expansion correlated to the expansion of the enamel.



TERMINALS. In Ward Leonard resistors, special alloy terminals insure proper expansion and adherence to the enamel, are designed to provide strong anchorage. Every wire-to-terminal junction is joined mechanically first, then specially silver-brazed for lasting contact.

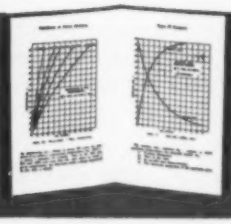


RHEOSTATS

RELAYS

MOTOR CONTROLS

CHROMASTER



Ward Leonard's complete engineering textbook, "Handbook of Power Resistors," $3. per copy.

DOW

MAGNESIUM FINDS INCREASING FAVOR AS DIE CASTING METAL

Advantages of light weight, easy machinability and competitive cost make Magnesium preferable for many types of die castings

Many manufacturers are taking a new look at magnesium as a die casting metal. In today's competitive markets, magnesium offers advantages that can't be overlooked.

Take light weight. Magnesium is the world's lightest structural metal. Where weight is a competitive factor, magnesium is the metal to use. A manufacturer of portable electronic dictation equipment found that nineteen castings in zinc weighed 13 pounds, 6½ ounces; and *in magnesium, 3 pounds, 10 ounces.* That's real weight saving!

Magnesium is well known as the easiest of all metals to machine. This in itself promotes economy. As an example, the manufacturer of a lubricating machine found that the cost of machining an oil reservoir cast in grey iron was $2.05 while machining the same part cast in magnesium cost only 80¢.

Cost-wise, magnesium is better than competitive in numerous applications. One large automotive manufacturer (an industry where cost is figured on a fractional basis) has found magnesium die castings to be the lowest in cost of any metal in a score of applications. Moreover, magnesium's long-time record of price stability is also an important factor.

Now's a good time to take a close look at magnesium. For the competitive markets ahead, magnesium can offer you many advantages. Your nearest Dow office can give you up-to-the-minute information. Or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

you can depend on DOW MAGNESIUM

DOW

window shopping costs nothing...
can save you plenty

It pays to "shop around" before you make your power transmission or conveyor chain selections. Because, in order to get the most for your money, you need the right chain for your designs. For example, a precision-finished roller chain is ideal for high speed drives. But, roller chain is not the economical, efficient choice for slow speed, heavy-duty service. A heavy-duty steel or cast chain may be your answer here. That's why it will pay you to "shop" through the *complete* Chain Belt line before you make your choice. There's a size and type to fit any power transmission or conveyor need.

Don't be handicapped by relying on a supplier with a limited line to answer all your needs. It may cost you more... may handicap the expected performance of your machines.

Your Chain Belt Field Sales engineer will be happy to assist you in making the exact chain selection that best fits your requirements. He is not prejudiced by the limitations inherent in an incomplete chain line... can recommend the chain that will give you the service you want... at the lowest possible cost. For complete information or engineering assistance, mail the coupon.

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EXPORT OFFICES: 4800 W. Mitchell St., Milwaukee; and 19 Rector St., N. Y. City.

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Gentlemen:
Please send me information on Rex and Baldwin-Rex chains
☐ For Power Transmission ☐ For Conveying ☐ For Tension Linkages
☐ Slide rule drive selector for slow to medium speeds

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Company.....*Dept.*.....

Address.....

City.....*State*.....

Your wet clutch may need a custom-compounded facing

A well-designed clutch may lose a lot of its inherent performance if the torque-engagement characteristics of its facing don't precisely fit its mechanical characteristics. That's why your wet clutch may need a facing material that's compounded to supply a particular combination of properties.

Of course, one of Armstrong's many standard friction materials may be exactly what you need. But if you need something special, Armstrong can supply it with a minimum of time and effort on your part.

You merely give us the pertinent data on your clutch design—which you can do easily on one of our Clutch Data Sheets. Then we will give you a selection of facings that seem most suitable, either in cork or combinations of cork and rubber, or cork and fiber.

If your field tests show that none of these materials gives you the performance you're looking for, and very often one will, then your test data can be used by Armstrong compounders either to modify an existing compound or create an entirely new one. Here's how they do it.

All Armstrong's Friction Materials are performance-tested under standard, controlled conditions on special, Armstrong-built test equipment. Your test data on the most promising of the facings are compared with the laboratory data on that same material. This comparison shows how it may need to be modified or which other Armstrong material may already offer the properties you need.

If a compound modification or a new compound is called for, Armstrong compounders ordinarily can come up with it quickly because their studies already have established what the effects are of many variations in formulation or operating condition. This has a double advantage for you. You can get a suitable facing with a minimum of experimental time and expense. You also have assurance that the material you select will do the best possible job in your particular clutch.

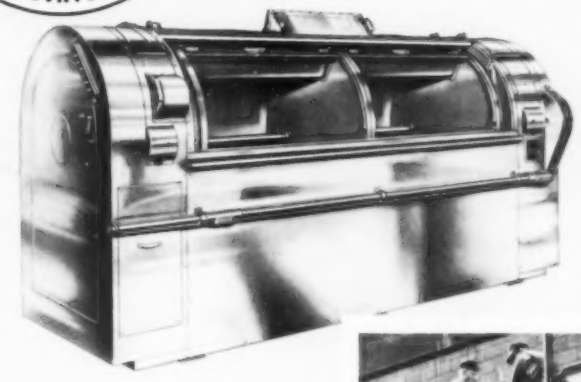
If you're working on a new clutch design now, or would like to improve the performance of an existing unit, write for a copy of our Clutch Facing Data Sheet. We'll be glad to study the data you submit, suggest suitable materials, and supply samples for experimental use. Write Armstrong Cork Company, Industrial Division, 7211 Irvin Street, Lancaster, Pennsylvania.

ARMSTRONG'S FRICTION MATERIALS

New facts for your file on U·S·S STAINLESS STEEL

MANUFACTURED FROM USS STAINLESS STEEL UNITED STATES STEEL

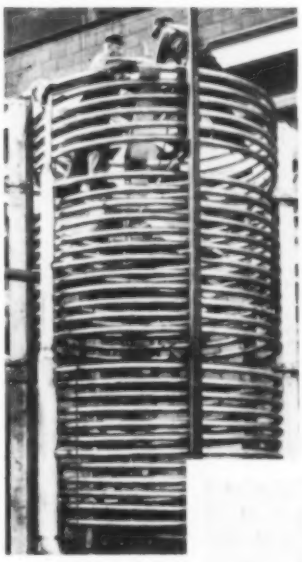
Corrosion-resisting Stainless Steel now used in American Laundry Machinery Co. Cascade Washers



Stainless Steel, with its superior corrosion resistance and smooth, durable, easy-to-clean surface, is now being used for many of the parts in American Laundry Machinery Company's Cascade Washers.

The tub, the cylinder, drive guards, supply trough and instrument panel are all Stainless Steel. Most of these parts come in direct contact with the hot, soapy water, and Stainless Steel will provide long, satisfactory service life under such conditions.

Stainless Steel tubing selected for coil assembly of penicillin fermenter



In fabricating a custom-built, 15,000-gallon fermenter tank for one of the nation's leading penicillin manufacturers, The Pfaudler Company, Rochester, N. Y., used 3" O. D. Stainless Steel tubing for the coil assembly.

Stainless Steel's corrosion resistance, as well as its excellent sanitary properties, led to its selection for this important application.

Take advantage of Stainless Steel in your designs and in your selling

These applications are typical of the way Stainless Steel can be used to improve design and add sales appeal in a wide variety of products. Stainless' wide range of valuable properties make it the ideal material for many, many jobs.

Put Stainless to work for you. It will pay its own way and give you a good return on your investment—especially when it is perfected, service-tested U·S·S Stainless Steel.

Thermador cooking units take advantage of Stainless Steel's beauty and durability

The beauty, the ease of cleaning and the long-lasting qualities of Stainless Steel are used to full advantage in the line of separate cooking units manufactured by Thermador Electrical Manufacturing Company, Los Angeles, California.

Thermador makes good use of the sales appeal of the unique properties of Stainless Steel and finds its fabricating qualities make it ideally suited for applications like this.

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

New facts for your file on U·S·S

Made of U·S·S MAN-TEN steel, vital parts of land leveler and ditching plow weigh less but wear longer

Switch to U·S·S MAN-TEN steel solves serious forming problem, increases rigidity, saves weight

Lyon Metal Products, Inc., Aurora, Illinois, originally specified 20-gage carbon steel for the seats of these steel folding chairs. In press forming, the seat section showed a tendency to crease across the bracing angle. Although the crease was scarcely noticeable to the touch, it became very obvious under certain light reflections and created sales resistance.

To overcome this, Lyon switched to cold-rolled U·S·S MAN-TEN steel in 22-gage weight. This strong, tough steel gave greater rigidity to the seats and completely eliminated the creasing or buckling. Although weight saving was not a factor in the selection of U·S·S MAN-TEN, the change resulted in a weight reduction per seat blank of three-quarters of a pound, which appreciably cuts the steel tonnage required, keeps manufacturing costs down, lowers shipping costs.

The Eversman Manufacturing Company, Denver, Colo., have used U·S·S MAN-TEN and other U·S·S High Strength Steels in their famous line of agricultural implements for a good many years. Recently they wrote:

"We had been using ¼" mild carbon steel for the curved center-cutting blade of our Model 289 Land Leveler and wanted to reduce its weight. We were able to do this by changing to 10-gage hot-rolled MAN-TEN steel which weighs 44% less. Then we did some checking with our dealers and find that the MAN-TEN steel blade wears 20% longer.

"The Eversman Ditcher is a new product with us. To keep it as light and strong as possible and give it good resistance to wear, we naturally decided on MAN-TEN steel for the curved wings as they perform a function similar to the cutting blade on the Leveler. The MAN-TEN steel gives us a very strong durable section which can take a great deal of punishment without being bent out of shape as happens with ordinary carbon steel."

In hard-working farm equipment like this and in heavy-duty earth moving and materials handling equipment such as cranes, power shovels, drag line excavators, scrapers, bulldozers, trenchers, snow plows, etc., wherever parts are subjected to severe wear and punishing loads and stresses, the high resistance to abrasion, high endurance limit and superior yield point values of U·S·S MAN-TEN steel can be utilized at little or no increase in cost to reduce weight, increase capacity and prolong life. It will pay you to examine the possibilities of this service-tested steel.

Manufacturer of heavy-duty trailers uses MAN-TEN steel for maximum strength with minimum weight

If you are building equipment that requires strength, toughness and stamina beyond the ordinary, this letter from the Talbert Construction Equipment Co. of Summit, Ill., should be of interest.

They write, "One of the principal problems confronting us as manufacturers of heavy-duty hauling equipment is the control of design so as to insure adequate strength at critical points with minimum weight. The extremely heavy loads our trailers are designed to handle—up to 100 tons—called for the use of very heavy structural sections in carbon steel or the adoption of a steel that would give us the high strength needed without increasing the dead weight. We found the answer in U·S·S MAN-TEN steel, and our main beams, center sill and side channels are built of this grade of high strength steel, with excellent results.

"In welding MAN-TEN steel to mild steel, good results are obtained using a mild steel welding rod. In welding MAN-TEN to MAN-TEN, best results are secured using a High-Strength welding rod."

U·S·S HIGH STRENGTH STEELS

U·S·S COR-TEN · U·S·S MAN-TEN · U·S·S TRI-TEN

HIGH STRENGTH STEELS

1933 USS HIGH STRENGTH STEELS UNITED STATES STEEL 1953

TWENTY YEARS OF PERFORMANCE

Roof purlins of U·S·S MAN-TEN steel weigh no more than carbon steel, carry 72% more live load, cost 22% less to use

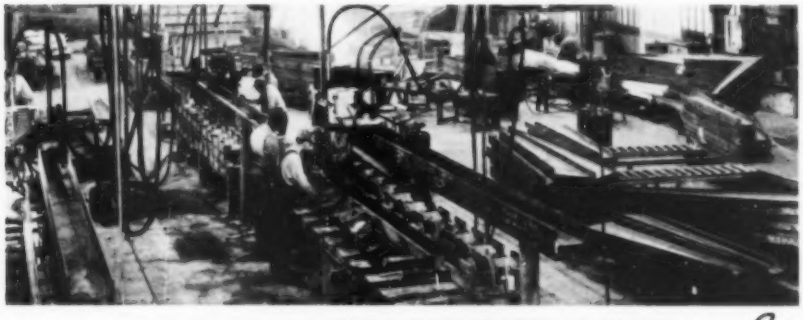
Butler Manufacturing Co., Kansas City, Mo., a leading producer of pre-engineered buildings, illustrates perfectly how U·S·S MAN-TEN steel often provides more effective strength per dollar, and is therefore more economical than any other material.

Says Mr. W. B. Larkin: "At present we are making generous use of U·S·S MAN-TEN steel for roof purlins and side wall girts on our standard rigid frame buildings. By a rolling and press brake operation, MAN-TEN steel strips are formed into Z-sections approximately 6½" high with flange 2½" wide.

"Originally we made these members of 14-gage carbon steel which, when properly spaced, carried a roof load of 15 lbs. per sq. ft. The expansion in our business required that we furnish a building for heavier roof loads. We were limited by our fabrication equipment which is very expensive, so it was decided to use high tensile material of the same thickness to carry this heavier roof load. The use of U·S·S MAN-TEN steel in the same gage gave us the necessary increase in load-bearing capacity, as follows: 14-gage carbon steel purlins, weighing 62 lbs., supported a load of 15 lbs. per sq. ft.

"In contrast, 14-gage U·S·S MAN-TEN steel purlins, in the same weight, supported a load of 26 lbs. per sq. ft. Result: 72% increase in load-bearing capacity with a 22% decrease in cost ratio per pound of live load capacity.

"You can see from this that even though the base price of U·S·S MAN-TEN is higher than carbon steel, when compared with the job it does . . . is less expensive than regular steel. We are now considering the use of MAN-TEN steel for the fabrication of complete rigid frames for larger buildings."



MECHANICAL PROPERTIES OF U·S·S MAN-TEN STEEL	THICKNESSES ½ Inch and Under	Over ½ to 1½ Inch Incl.	Over 1½ to 3 Inches Incl.
Yield Point, min., psi	50,000	45,000	40,000
Tensile Strength, min., psi	75,000	70,000	65,000
Elong. in 2 In., min., per cent	20	—	22
Elong. in 8 In., min., per cent .180 In. and heavier	18	19	20
Cold Bend	180° D=1t	180° D=2t	180° D=3t

The minimum yield point and tensile strength requirements will be reduced by 5,000 psi when the material is specified in the annealed or normalized conditions. ASTM Standard Specimens, minimum number of tests and ductility modifications apply.

ADDITIONAL TYPICAL PROPERTIES FOR ENGINEERING GUIDANCE

Resistance to atmospheric corrosion	2 times carbon steel
Compressive Yield Point, psi	Equal to tensile Yield Point
Shearing Strength, psi	Equal to ¾ Tensile Strength
Modulus of Elasticity, psi	28,000,000 to 30,000,000
Endurance Limit (as rolled, avg.), psi	39,000
Charpy Impact, keyhole notch (as rolled, room temp. avg.), ft. lb.	30
Coefficient of Expansion per degree F, 70° to 200° F	.0000063

Send for the MAN-TEN Book, get complete information

United States Steel Corporation
525 William Penn Place, Room 2811-U
Pittsburgh 30, Pennsylvania

Please send me a copy of your book "U·S·S MAN-TEN."

Name ..... Title .....

Company .....

Address .....

City ..... State .....

USS

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UNITED STATES STEEL

New facts for your file on

U·S·S CARILLOY STEELS

U·S·S CARILLOY steel cushions bone-rattling jolts on the world's finest medium tank

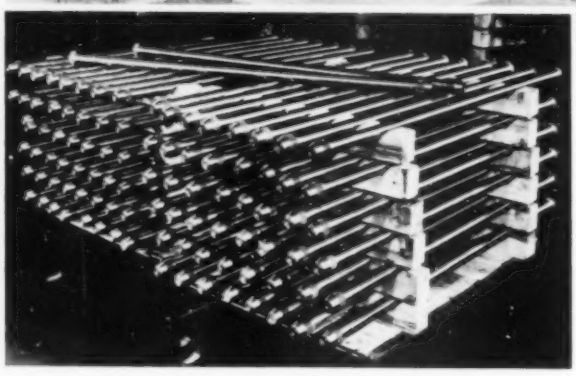
THE army's amazing new Patton 48 not only moves faster, shoots straighter, and offers better protection to the tank crew, but it has a vastly improved suspension system that features torsion bar springs made of U·S·S CARILLOY steel. As a result, it rides lower and more level and with less jarring than World War II models.

During rugged field tests, this 45-50-ton tank rolls along at more than 30 miles an hour, knocks down telephone poles and houses, rumbles over deep trenches and scales 3-foot walls. All the while, the CARILLOY steel torsion bars that support the driving wheels flex, twist, and vibrate. They smoothly absorb most of the jolts as the tank forges ahead.

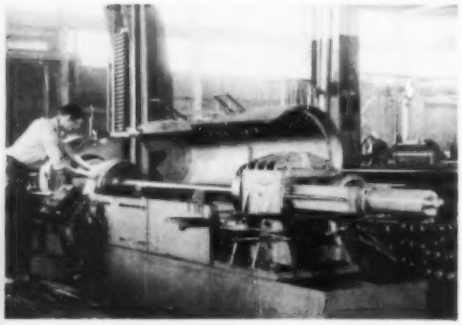
Torsion bars withstand this heavy pounding . . . and do a better job of cushioning these shocks than previous spring systems. What's more they take less space, so the tank can be built closer to the ground, has a lower silhouette than other models.

U·S·S CARILLOY 8660 is a Ni-Cr-Mo electric furnace steel which possesses the required hardenability needed in these torsion bars. It will produce a minimum hardness of 55 Rockwell "C" at $^{3}/_{16}$", from the quenched end in the standard End Quench hardenability test. It has exceptionally good surface and subsurface qualities.

Both the United States Army Ordnance Corps and the spring manufacturer, Maremont Automotive Products, Inc., are well satisfied with this excellent performance.



HERE are the CARILLOY steel torsion bars ready for shipment. Torsion bars are used on the Patton 48 and others so that the tanks can be built closer to the ground, giving a lower silhouette.



ON THIS TWISTER at the Cicero plant of Maremont Automotive Products, Inc., the finished CARILLOY steel torsion bars are prestressed before shipment to the tank manufacturer.

U·S·S CARILLOY steels are doing many tough jobs like this on both military and civilian products. So no matter what type of steel problem you have, we have probably met and licked one very much like it before. We can help you solve yours. Just get in touch with our nearest District Office, or write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS

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TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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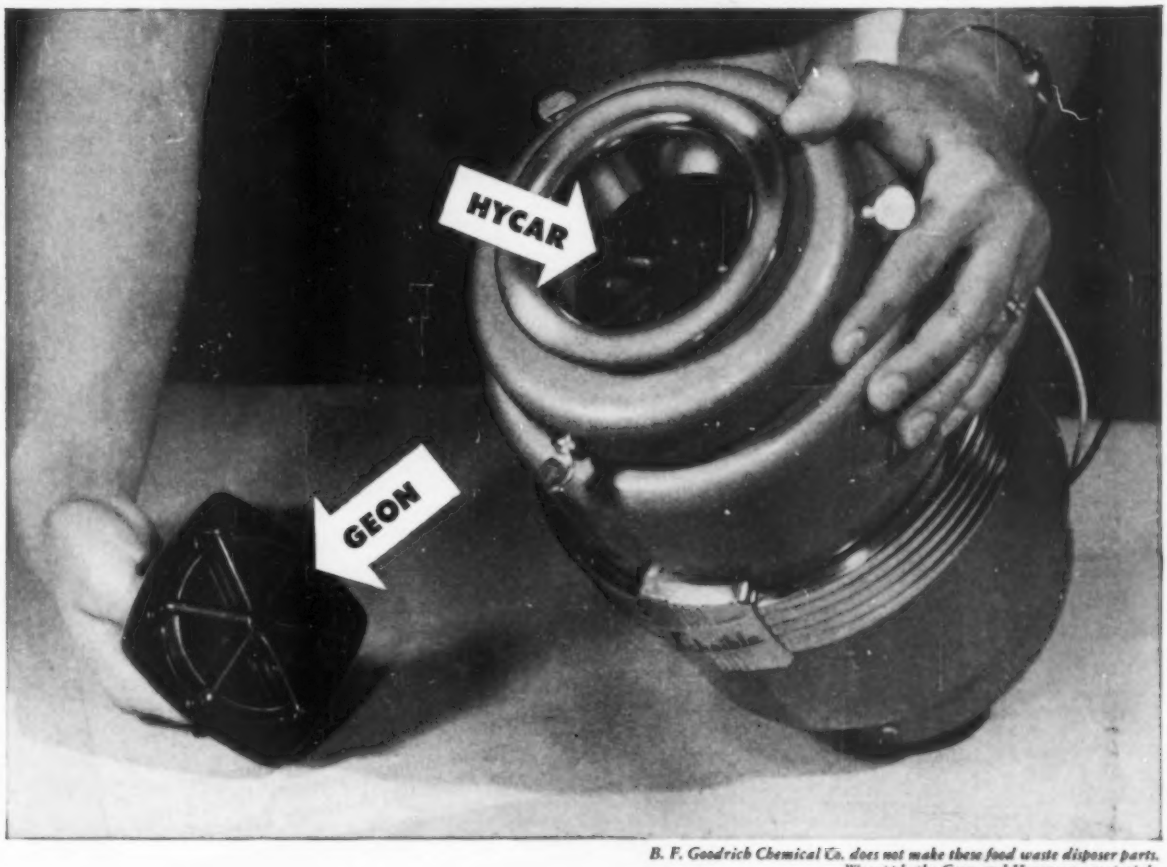
UNITED STATES STEEL

Another new development using

B. F. Goodrich Chemical *raw materials*



B. F. Goodrich Chemical Co. does not make these food waste disposer parts. We supply the Geon and Hycar raw materials.

FOOD WASTE DISPOSER EFFICIENCY IMPROVED with Geon and Hycar

HERE'S a food waste disposer with two unique features—a flexible stopper made of Geon vinyl plastic and a shock absorber and throat baffle made of Hycar American rubber.

The stopper replaces conventional metal ones, will not chip, crack, mar dishes or sink if dropped. Fitting tightly in the opening, it makes the sink drain leak-proof. It can be used as a food scraper—food acids or stains can't harm it. In tests with all types of detergents and soaps, this Geon stopper retained its flexibility and brilliant color.

The Hycar shock absorber and throat baffle, when compressed, prevents metal-to-metal contact of the sink and the disposer, eliminating noise and vibration. The baffles in the throat keep splash and small particles from leaping out of the shredding chamber—yet allow easy entry of food waste for shredding. This Hycar part retains its resilience, helps dampen vibration, and resists greases, alkalies and mild acids common to kitchen work.

Perhaps there's an idea here for you in what Geon and Hycar can do. These versatile materials are complementary, offer some of the same properties. And each has specific advantages that may help you solve design problems, simplify operations, improve or develop more saleable products. For technical advice, please write Dept. HT-6, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
American Rubber

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

U. S. Air Force crash trucks and rescue vehicles by American-LaFrance-Foamite Corp., Elmira, N. Y., use Revere Aluminum.

Aluminum Conductor Busway, light and economical, by Bull Dog Electric Products Co., Detroit, Mich., uses Revere Aluminum (EC Grade) Bar.

Industry Depends Upon The Versatility Of REVERE ALUMINUM

Revere meets the requirements of industry with a wide range of aluminum alloys in extruded shapes, coiled sheet, drawn tube, electrical bar and forgings. And industry knows the fine, uniform quality of Revere Aluminum. Each customer's requirements, based on their specific uses of Revere products, receives careful attention by Revere quality control.

For assistance in the efficient manufacture of products using aluminum, you are invited to utilize Revere's Technical Advisory Service.

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REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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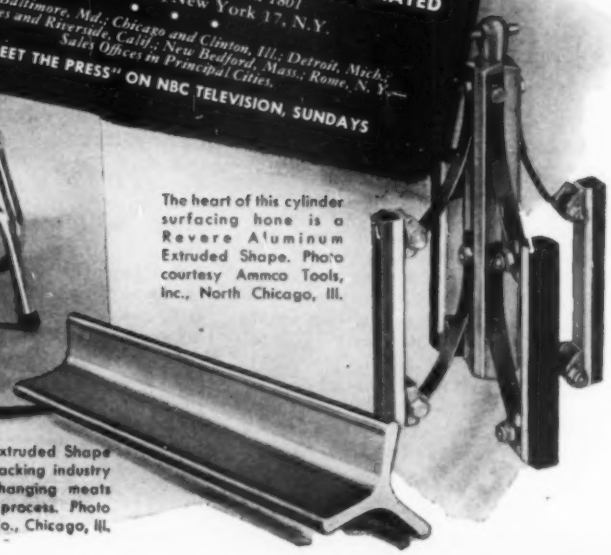
Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.— Sales Offices in Principal Cities.

SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

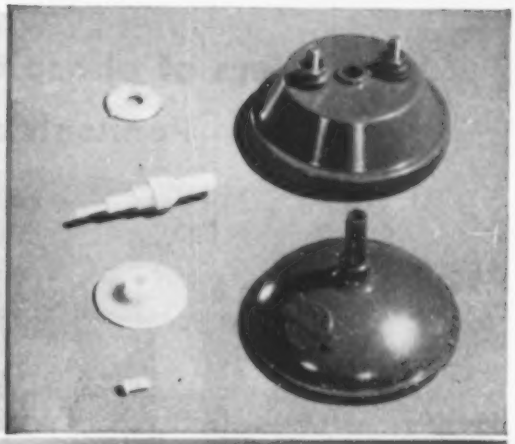
Many makers of indoor and outdoor chairs and furniture use Revere Aluminum Tube. This chair by Lawnlite Co., Miami, Florida.

The heart of this cylinder surfacing hone is a Revere Aluminum Extruded Shape. Photo courtesy Ammco Tools, Inc., North Chicago, Ill.



A Revere Aluminum Extruded Shape is used by the meat packing industry as smoke-sticks for hanging meats during the smoking process. Photo courtesy The Globe Co., Chicago, Ill.

Parts of Du Pont nylon are strong, can't corrode, need no oiling...



...help automatic starter withstand vibration, give long, trouble-free service

Why not investigate how this unique engineering material—DU PONT NYLON —can help improve your product?

These six parts, as used in a new starter developed for automatic transmission cars, demonstrate how the unique properties of Du Pont nylon can help engineers develop more efficient products.

Du Pont nylon is strong and durable. Parts made of it withstand shock and vibration. Nylon can't corrode, is unaffected by most common chemicals. Du Pont nylon is light in weight, heat-resistant and remarkably resilient. Parts resist wear and abrasion, provide quiet operation with little or no lubrication. And Du Pont nylon's electrical insulating properties insure positive operation.

Perhaps the valuable properties of Du Pont nylon can help you develop a new or improved product or process. For further information on Du Pont nylon write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 1011 Du Pont Bldg., Wilmington 98, Delaware.

Check all these outstanding properties of Du Pont nylon—

- √ **TOUGHNESS**—Nylon is virtually unbreakable, even at low temperatures.
- √ **HEAT RESISTANCE**—Nylon is capable of continuous operation to 250°F.
- √ **ABRASION RESISTANCE**—Nylon resists wear, scuffing and gouging.
- √ **STRENGTH, RESILIENCY**—Nylon absorbs shock without chipping or cracking . . . is strong in thin sections.
- √ **LIGHT WEIGHT**—Nylon's specific gravity is 1.14.
- √ **CHEMICAL RESISTANCE**—Nylon is unaffected by most common chemicals.
- √ **LOW COEFFICIENT OF FRICTION**—Nylon has excellent bearing characteristics—provides quiet operation with little or no lubrication.

Nylon parts molded by United Plastics Industries, Inc., Vassar, Mich., for Automo Corp., Saginaw, Mich.

DU PONT
REG. U.S. PAT. OFF.
NYLON
Plastic
Better Things for Better Living
. . . through Chemistry

To users of phosphate coatings,

Pennsalt offers the

New FOSBOND

A complete system linking together supplies and operations . . .

a complete set of compounds...

for cleaning, pickling, phosphating, and rinsing . . .
all from one reliable source—Pennsalt

applied in a balanced cycle...

tailor-made by Pennsalt engineers to fit your
operations and equipment

serviced and maintained...

by experienced field servicemen on a
regular, scheduled basis

advertised and merchandised

to help pre-sell your quality finish
to wholesalers, dealers, and consumers

At Pennsalt's famous Whitemarsh Research Laboratories, where Fosbond was developed, there are unusually fine testing facilities at the disposal of manufacturers using the Process.

Process

for trouble-free processing . . . for a better, longer-lasting finish

Now Pennsalt, long a pioneer in the metal processing field, offers everything you need for uniform, trouble-free phosphating of steel and zinc!

Products and processing have been engineered to (1) provide an excellent pre-paint corrosion resistant surface, (2) offer simplified operation through the entire balanced cycle, (3) be usable with standard equipment, and be compatible with standard organic finishes.

Every product and technique now offered has been fully field-tested for two years or more. Experienced Pennsalt specialists are ready to come into your plant to show you how to get the most from this advanced system. Furthermore, once the cycle has been introduced in your plant, these men will continue to help you maintain a trouble-free system.

There is no fee for the Process. Reasonably priced chemical products are your only expense.

How's this for proof?

To prove what we say about the Fosbond Process, we offer this service: tell us (1) type of metal to be coated, (2) kind of phosphate coating now used, (3) method of application to be used, (4) kind of organic finish to be employed, and (5) conditions which finish must meet. In turn, we will supply either panels coated by means of the Fosbond Process, or Fosbond chemicals for your use in preparing panels. Then, subject these panels to whatever tests you wish . . . and *you* be the judge.

Which of your products and operations can benefit from the Fosbond Process? Give us details on these items; we'll be able to answer your questions more specifically. Write to Metal Processing Department, 422 Widener Building, Philadelphia 7, Pa.

A better start for your finish

Pennsalt Chemicals

PENNSYLVANIA SALT MANUFACTURING COMPANY

A Valuable Fosbond Extra!

The Fosbond Process has received the famous *Good Housekeeping Guaranty Seal.* Manufacturers who qualify may affix to their products the colorful Fosbond emblem which incorporates the Good Housekeeping seal. To help Fosbond users get full advantage from this merchandising "plus", the Fosbond story is told in ***The Saturday Evening Post, Good Housekeeping, U.S. News & World Report, Business Week, Electrical Merchandising, Department Store Economist, Implement & Tractor,*** and ***Office Appliances.***

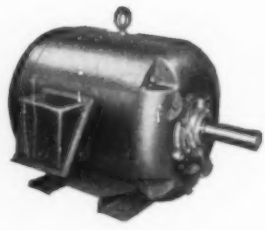
Wagner Motors provide the power to machine 72 tractor cylinder blocks per hour

This Cross Transfer-matic was built for Ford Motor Company for use in its Tractor and Engine Division. It mills, drills, bores, taps, reams and chamfers 72 tractor cylinder blocks in an hour, and is equipped throughout with Wagner totally-enclosed motors. (A total of 32 motors, ranging from ¾ to 15 hp.)

Machine tools powered with Wagner totally-enclosed motors are assured freedom from excessive downtime caused by motor failure, because these motors are fully protected against damage from steel-filings, chips, dust, dirt, fumes and moisture.

For your requirements, there is a Wagner Motor to fit every need—a complete line for all current specifications, with a wide variety of enclosure types and mountings. Bulletin MU-185 gives full information. Do you have a copy?

A nearby Wagner engineer will be glad to help you select the *right* motors for your next application. Consult the nearest of our 32 branch offices, or write us.



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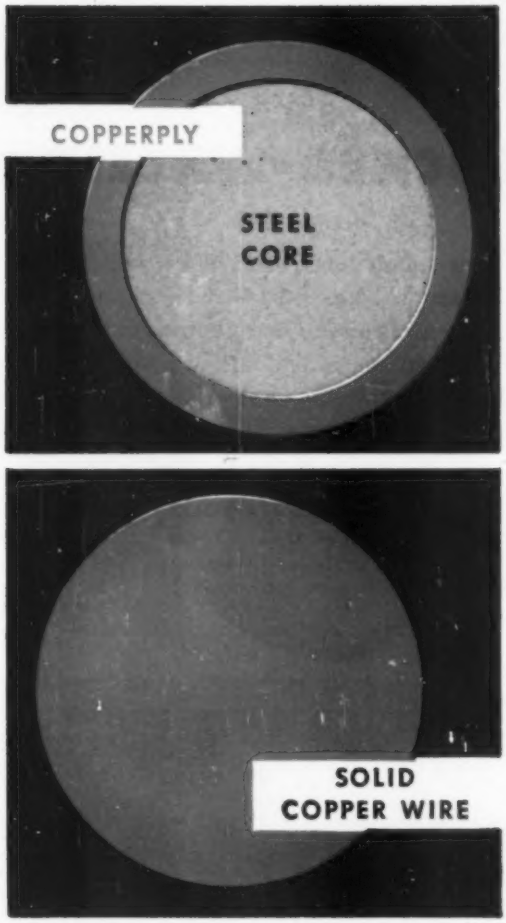

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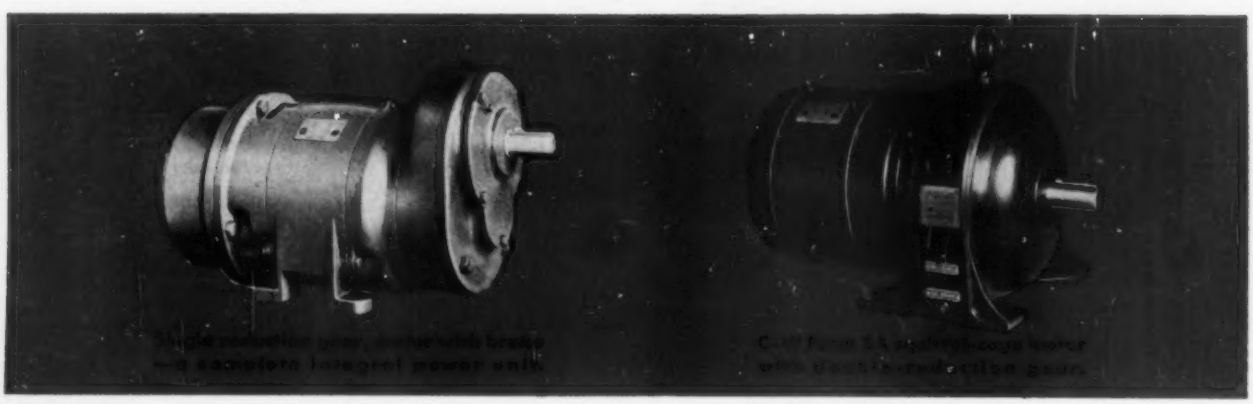

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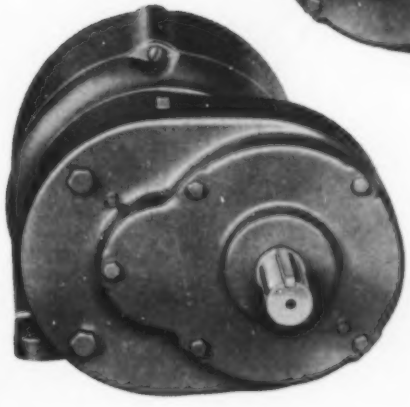

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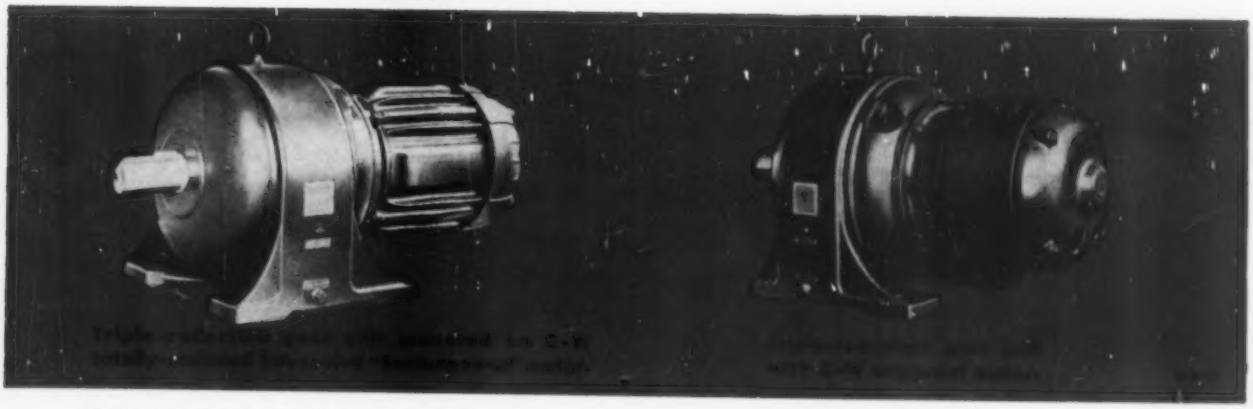

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combine light weight and high strength with pleasing appearance and high production potentials...with **MADISON-KIPP** zinc and aluminum die castings

THE CASTING here illustrated requires a minimum of secondary operations. Cast-in are side slots and recesses, top holes and counter-bores, bottom ribs and bosses. The casting is strong and light and is produced with a smooth finish.

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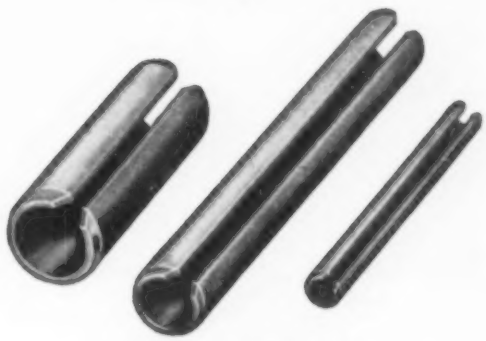
Every major aircraft now being assembled relies on the vibration-proof holding power of ELASTIC STOP nuts. Only ESNA manufactures a complete line of all types and sizes of self-locking nuts.

Rollpins


dia. from 1/16" to 1/2"

Rollpins are slotted, tubular steel, pressed-fit pins with chamfered ends. They drive easily into holes drilled to normal tolerances, compressing as driven. Extra assembly steps like hole reaming or peening are eliminated. Rollpins *lock* in place, yet are readily removed with a punch and may be reused.

Cut assembly costs by using Rollpins as set screws, positioning dowels, clevis or hinge pins. Specify them in place of straight, serrated, tapered or cotter type pins.

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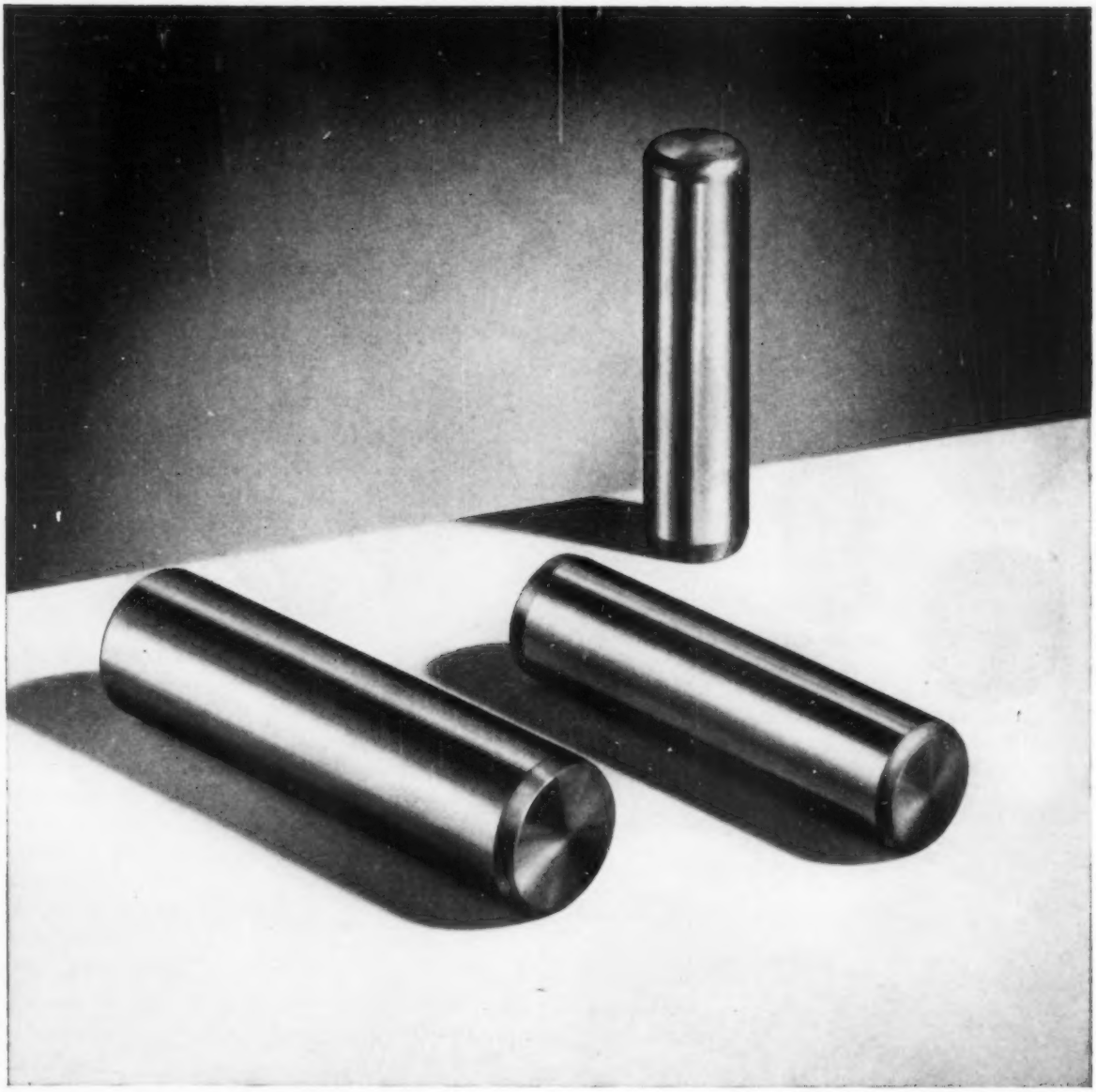
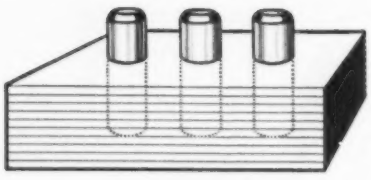
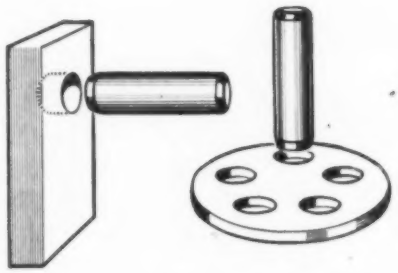


UNBRAKO PRECISION-GROUND ALLOY STEEL DOWEL PINS feature the following: formed ends which won't chip, 60-62 Rockwell "C" Scale surface hardness; 6 micro-inch maximum surface finish; 50-54 Rockwell "C" Scale core hardness; 150,000 psi average single shear strength; ±0.0001" diameter tolerance; 2 standards—blue label pins, .0002" oversize for nominal press fit requirements and red label pins, .001" oversize for use as repair pins.



As fasteners for laminated sections, machine parts. As roller bearings in casters, truck wheels, etc.



Use UNBRAKO Dowel Pins as plug gages in various production operations, as guide pins, as stops, as wrist pins, hinges and shafts.

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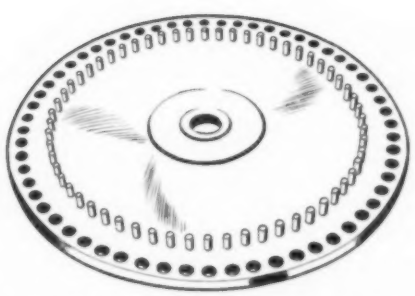

As position locators on indexing machines, for aligning parts, as feeler gages in assembly work, as valves and valve plungers on hydraulic equipment.

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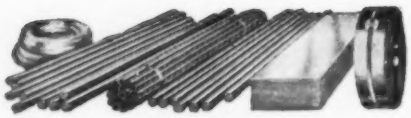
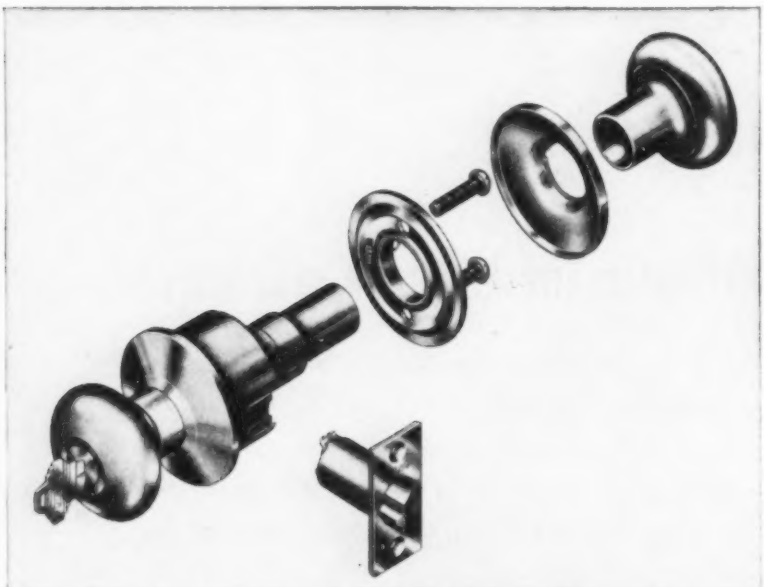


BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport BRASS CO. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND. — IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Exploded view of cylindrical lock, complete with key in knob, shield, escutcheon, latchbolt and screws. Courtesy Schlage Lock Company, San Francisco, California.

Brass for Modern Locks
...Chosen for Dependability and Beauty

A good door lock is expected to function regardless of age or inattention. This may explain why brass has long been the metal of choice for manufacturers of highest quality locks.

Brass has many qualifications which make it ideal for this application. It is easily worked and lends itself readily to ordinary factory operations such as machining, drawing, stamping, soldering, polishing, and plating.

Besides corrosion resistance, brass has the added advantage of a low coefficient of friction. Consequently, wear on rubbing parts is reduced to a minimum. That's why a brass lock will function smoothly with little or no lubricant.

Brass used for exterior parts such as knobs and escutcheon plates is highly decorative, with a warm, bright color, especially when highly polished. Constant use will also keep the metal shiny.

The lock illustrated is not only made from enduring brass but is exceptionally well-designed. It is of the key-in-knob type with the key in the door knob.

Originated in 1923

This lock was developed from the push button lock, a design first introduced in 1923. It is said to have changed the art and method of making door locks throughout the world. For one thing, it received ready acceptance because it required very simple installation: Only two holes in the door are needed. Thus much time and highly-skilled labor formerly consumed by mortising are eliminated. These locks are so designed that they are interchangeable once the necessary holes have been bored.

Free Machining Brass

The pin tumbler cylinder lock is a difficult part to make. This vital precision part must undergo multiple drilling, broaching, and threading, besides over-all machining. Ledrite 6 Brass Rod has a machinability rating of 100 per cent and is excellent for these operations. Ledrite also meets high standards of quality, accuracy in dimensions, and provides a smooth finish free from burrs.

The latchbolt is also made from Ledrite 6 Brass Rod. Milling and sawing are easily performed with this alloy too.

The part for the pin tumbler cylinder is made from extruded shape Ledrite 6 Free Machining Brass. This item also requires considerable drilling.

70-30 Brass for Ductility

The door knob is a two-piece assembly made from 70-30 Brass strip. This alloy is very ductile and can be readily drawn. As it must be highly polished, care is taken to supply metal with a grain size which will impart suitable ductility with maximum smoothness of surface after forming.

The decorative escutcheon plates are also made from 70-30 brass. It is supplied in the annealed condition but with the minimum grain size for the highest polish with the least effort.

Technical Service

The use of the right metals with suitable tempers is essential if economies are to be made in metal goods fabrication.

Much information on copper-base alloys, as well as numerous tables and valuable working suggestions, are found in Bridgeport's "Technical Handbook." Available on request.

Bridgeport Laboratory will be glad to help you in your metal selections. Or, contact your nearest Bridgeport Brass office for your metal requirements. (522)

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the SURE way with . . . ENTHONE

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EBONOL "S" Processes for blackening steel to produce jet-black oxide coatings. Simple and economical to operate. Operating temperatures: EBONOL "S", 285-290°F., EBONOL "S-30", 295-305°F.

EBONOL "C" The quality black for copper and brass that meets all military specifications.

EBONOL "Z" A durable, deep, rich finish for zinc plate or zinc alloy castings. Dull or glossy oxide black coatings are formed in from 5 to 10 minutes at 160-180°F.

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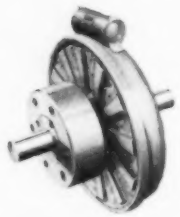
How Warner Electric Motion Control contributes to fully automatic operation of

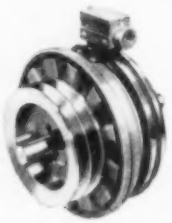
NEW HUNT HB-3 COTTON LOOM

Modern automaticity reaches another milestone in the textile industry with the advent of this remarkable new Hunt Cotton Loom. The loom *starts* (via pushbutton) with the speed of lightning. It *stops* automatically . . . within 1/400 of a second. No notches to engage, no clearances to take up, no solenoids or complicated linkages to slow operation. You increase productivity, decrease maintenance time and costs, provide foolproof control over machine motions, reduce spoilage. Your equipment can be similarly automaticized with Warner Electric Motion Control. For the complete story, contact your nearby Warner representative, or send coupon today.



Warner Electric Brakes are available with static torque ratings from 8 in. lbs. to 700 lbs. ft. Low wattage. Precise adjustment of speed and power. No wear adjustments. Rapid heat dissipation. Compact. Light in weight

Warner Electric Clutches are also available with static torque ratings from 8 in. lbs. to 700 lbs. ft. Even largest sizes require only 25-35 watts of direct current. Precise control of acceleration and power. Automatic wear take-up. Rapid heat dissipation. Easily adaptable.



Warner Electric Brakes and Clutches provide 5 important new features for users of Hunt Cotton Looms

1 *Accurate, prepositioned stops*—if warp end is down, loom stops automatically with the harness level. If a filling breaks, loom stops with shed wide open. Manual pushbutton stop causes loom to stop with the harness level. Result—a lightened work load on the weaver, shorter shut-down time.

2 *Reduced maintenance*—cushioned starts and stops assure long life for all loom components. Acceleration tests indicate life expectancy in excess of 50 years for the Warner Clutch and Brake. Amazingly simple—they never need adjustment.

3 *Fewer mechanical parts* required for starting and stopping motions. Less chances for trouble, lower repair costs, smaller inventory of spare parts add up to more production at higher profit.

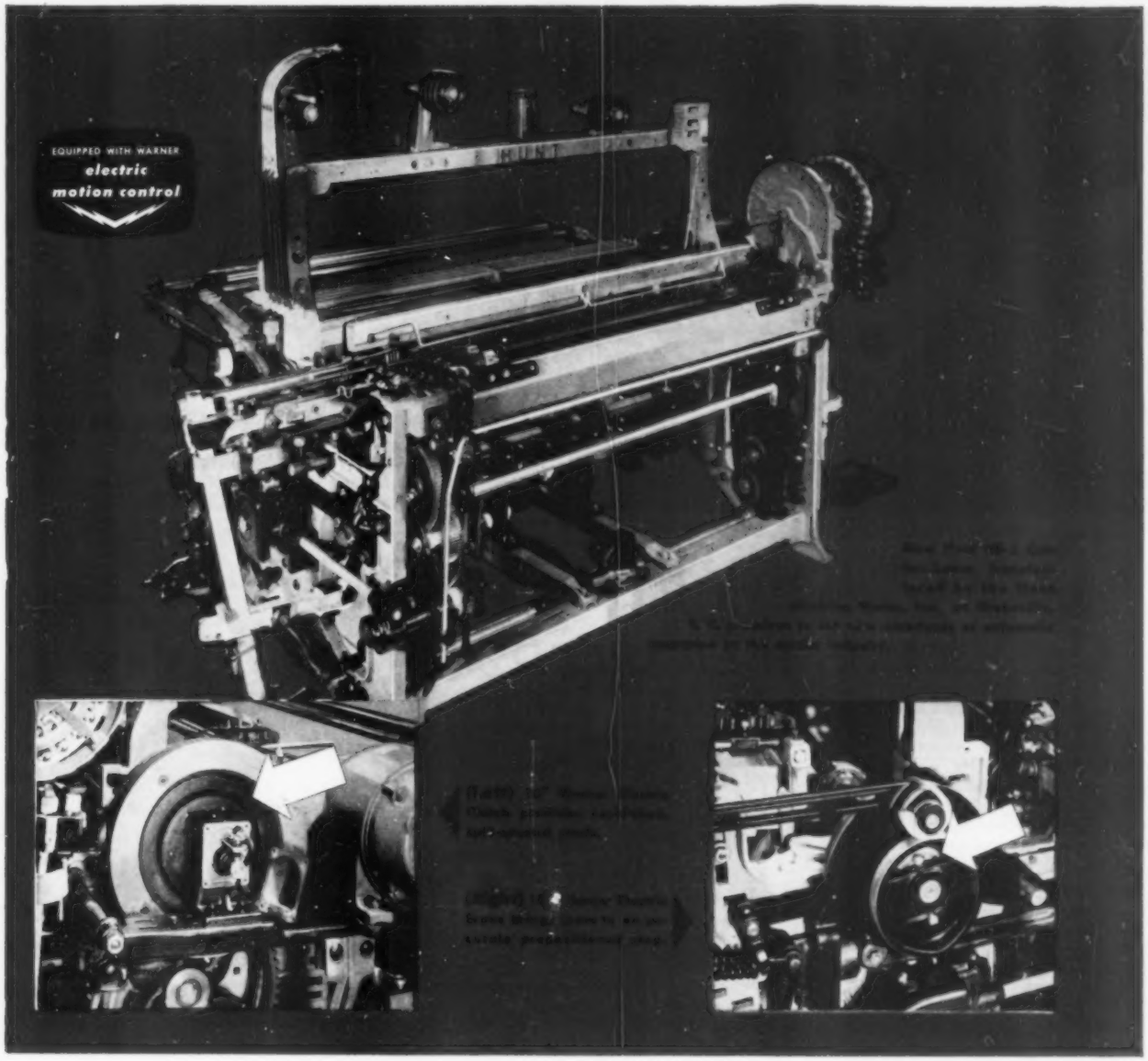
4 *"Inching" the loom* smoothly with pushbutton control is a simple matter, saving the manual labor of turning the handwheel.

5 *Electric signals* to counters help management determine stoppages due to warp preparation and quality, or filling quality.

WARNER

ELECTRIC BRAKES & CLUTCHES

FOR INDUSTRIAL APPLICATIONS



Warner Electric Brakes, Clutches and Clutch-Brakes give you new, unique simplicity of design and operation. There are only two main parts, an armature and magnet. Operation is by *electro-magnetic*, instantaneous engagement and release of friction surfaces. Torque ratings are extremely high for their small size and light weight. No coasting or slipping when "locked in." Easily designed into original equipment. Readily adapted to automatic cycles and remote control by limit switches, relays, electric eyes, pushbuttons, etc. Rate of application is accurately controlled to synchronize motions—give exact degree of speed and power required for your machine operation.

CONTROL ENGINEERING SERVICE . . . Warner offers complete application and control engineering service and field assistance. If you have a clutching, braking, tensioning, indexing, or speed-control problem, consult competent, experienced Warner brake and clutch specialists for reliable recommendations on torque, heat, electrical controls, capacity, etc.

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THIS MONTH'S MOTOR TIPS

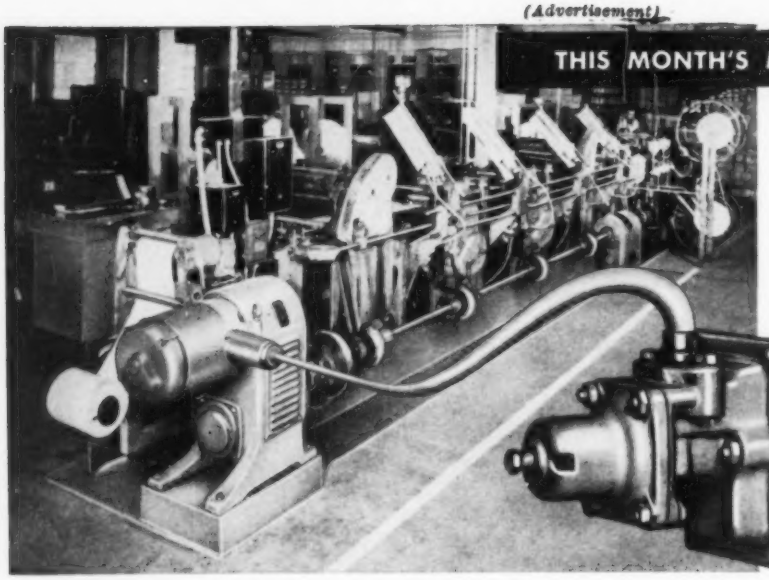


FIG. 1—Pneumatic control for Varidrive motor, permits quick speed changes from any remote control station. Photo shows Varidrive operating film processing equipment.

REMOTE CONTROLS AND SPECIAL HOOK-UPS OF VARIDRIVES GAIN POPULARITY

NEW DEVELOPMENTS in *VARIABLE SPEED* MOTOR DRIVES

RECENT innovations in variable speed drives include new and improved types of remote control equipment. Beyond the purely functional duty of a variable speed motor, such as a Varidrive, the latest methods of controlling it open up new adaptions to machines and equipment.

Motors cannot always be placed in a location convenient to the operator. In the case of fixed-speed motors this doesn't matter much because the operator has only to push a button to stop or start it, even if the motor is in the secluded center of a maze of machinery. But now, the manufacturers of the U. S. Varidrive motors have developed a complete line of remote controls to start, stop and regulate speeds sensitively set to a split rpm. Consequently a Varidrive motor can now be set in any location best positioned for the most compact and efficient hook-up and the operator can control it a mile away if necessary.

MECHANICAL AND ELECTRICAL

Remote controls of Varidrives may be basically divided into two classes, mechanical and electrical. The mechanical arrangements permit the use of extensions of the control dials straight out or universally positioned. For example, a Varidrive high up out of reach can be controlled from the floor by a simple extension supplied by the manufacturer. An excellent feature of the Varidrive control dial is that it is always located at the operator's station where he can dial from the slowest to the highest speed and read the calibrations of speed during dialing.

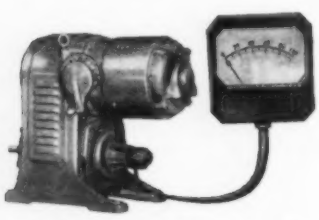


FIG. 3—Speed indicator tells Varidrive rpm at any distance. Can operate with push button if preferred.

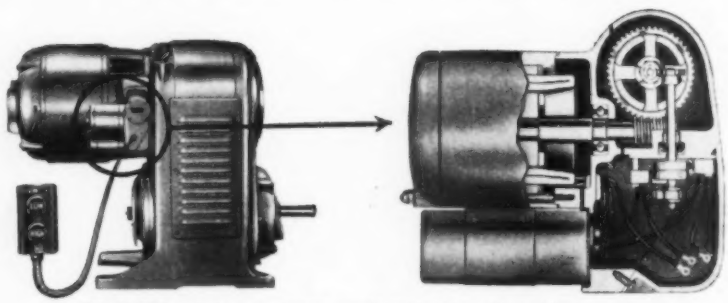


FIG. 2—ERC control motor changes speeds on Varidrive with push-button control.

For electrical controls, numerous arrangements have been perfected, of which one of the most popular is the Varidrive's Type ERC heavy-duty control motor. (Fig. 2.) Intead of the dial, this motor, which is 1/15 h.p., 1800 rpm, is attached to the control mechanism. It is a ruggedly designed auxiliary motor of the reversible capacitor type and has a low inertia rotor for quick stop, with push button control. Its rugged worm drive actuates the Varidrive's speed control and it has adjustable limit switches.

SPEED INDICATOR

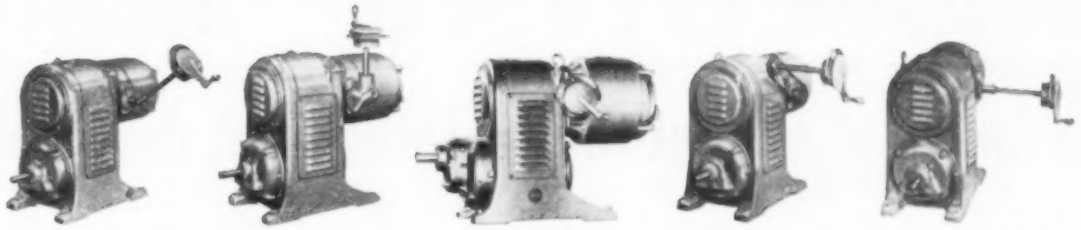
For electrically determining the speed of a U. S. Varidrive, a Type R1 speed indicator can be provided. (Fig. 3.) It consists of an enclosed tachometer with a generator mounted on and driven by the Varidrive. Speeds are indicated as per cent of maximum speed.

QUICK STOP CONTROLS

For machines requiring fast braking of Varidrive motors, the ICB brake is used. (Fig. 4.) It is mounted directly upon the Varidrive's take-off shaft, eliminating transmission of braking action through the belt. Such a device is ideal for "inching" or jogging. Its functional force is controlled by magnetic action.

The Warner automatic clutch is also used on many Varidrives, particularly on heavy presses for gradual pick-up to overcome heavy inertia. To properly adopt this improvement, the manufacturers of Varidrives provide special engineering service.

TYPES OF MANUAL REMOTE AND ON-MOTOR CONTROLS FOR VARIDRIVES



UNIVERSAL COUPLING
FIG. 6—For operating Varidrive at any angle to 30°. Rod any length.

RIGHT ANGLE DRIVE
FIG. 7—Control dial set at any of four 90° positions at right angle to standard setting.

ON-MOTOR CONTROL
FIG. 8—Not remote control, but showing location of control dial on motor.

CHAIN & SPROCKET
FIG. 9—Sprocket connected to rod by chain drive with two bearing supports.

DIRECT EXTENSION
FIG. 10—Rod connects Varidrive through sleeve coupling to project any length.

PNEUMATIC CONTROLS

When frequent motor speed changes are necessary, a pneumatic control is preferable. (Fig. 1.) Such a control as used in Varidrives includes a positioning unit embodying an air-operated plunger attached to the motor's speed changing device and a pressure regulator. Many methods may be used to operate the regulator such as pedal, lever, cam or wheel. By use of check valves and control station selectors, speed of the Varidrive can be changed from any number of control stations, or several Varidrives can be operated from one control. This device will operate on the customer's air supply of 60 or 100 psi or more.

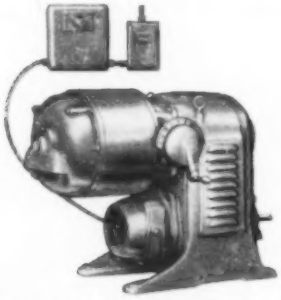


FIG. 4—Brake control instantly stops Varidrive. Excellent for "inching" motor.

AUTOMATIC SPEED REGULATION

In case a motor user operates such mechanisms as follower rolls and air cylinders which permit movement proportional to the desired speed range and can be mechanically linked, a compact lever actuator can be attached to a Varidrive motor. (Fig. 5.) Maximum/minimum speeds may be pre-set by means of adjustable speed stops located on the exterior.

DIRECTIONAL MANUAL CONTROLS

In what position a Varidrive is set in relation to the driven machine and operator's position of accessibility depends the location of the manual control dial. The case of the Varidrive is so designed that the control dial can be placed on the front side, back or top, and the take-off shaft positioned to right or left, high or low. This feature is of special interest to the design engineer who wants the most compact setting with greatest convenience to the operator.

OTHER VARIDRIVE INNOVATIONS

A notable improvement in Varidrives is the use of a double-ribbed varibelt which not only allows maximum flexing but permits use of smaller disc diameters. Greater horsepower can be developed within a smaller space. This newest of belt features reduces internal friction and provides greatest flexibility without sacrifice of strength. Dual varibelts, double-ribbed, are also available for high horsepower. For extra heavy duty, dual varibelts are provided for 25, 30, 40 and 50 horsepower.

FIG. 5—Automatic speed regulation to pre-set limits on Varidrive by lever control.

Of interest to those seeking a variable speed motor in fractional horsepower is the new VA Varidrive. It is an all-in-one power package in ¼, ⅓, ½ and ¾ horsepower ratings in one or 3-phase.

Those who have used Varidrive motors quickly recognize the improved output that can be obtained in almost any machine. Variable speed has become such an important factor in the mind of the aggressive design engineer that he has found it feasible to redesign equipment to take full advantage of variable speed potentials. With the availability of any desired Varidrive control system he finds new fields of application not heretofore possible.

A number of interesting engineering booklets have been written and profusely illustrated by the makers of U. S. Varidrive motors dealing with remote controls and variable speed applications. Copies may be obtained from U. S. Electrical Motors Inc., Box 2058, Los Angeles 54, California, or Milford, Connecticut.

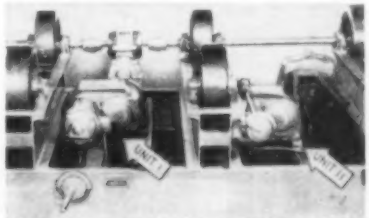


FIG. 11—Remote controls on Varidrives operating automatic welding machine.

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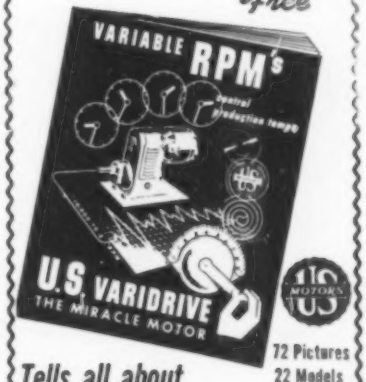

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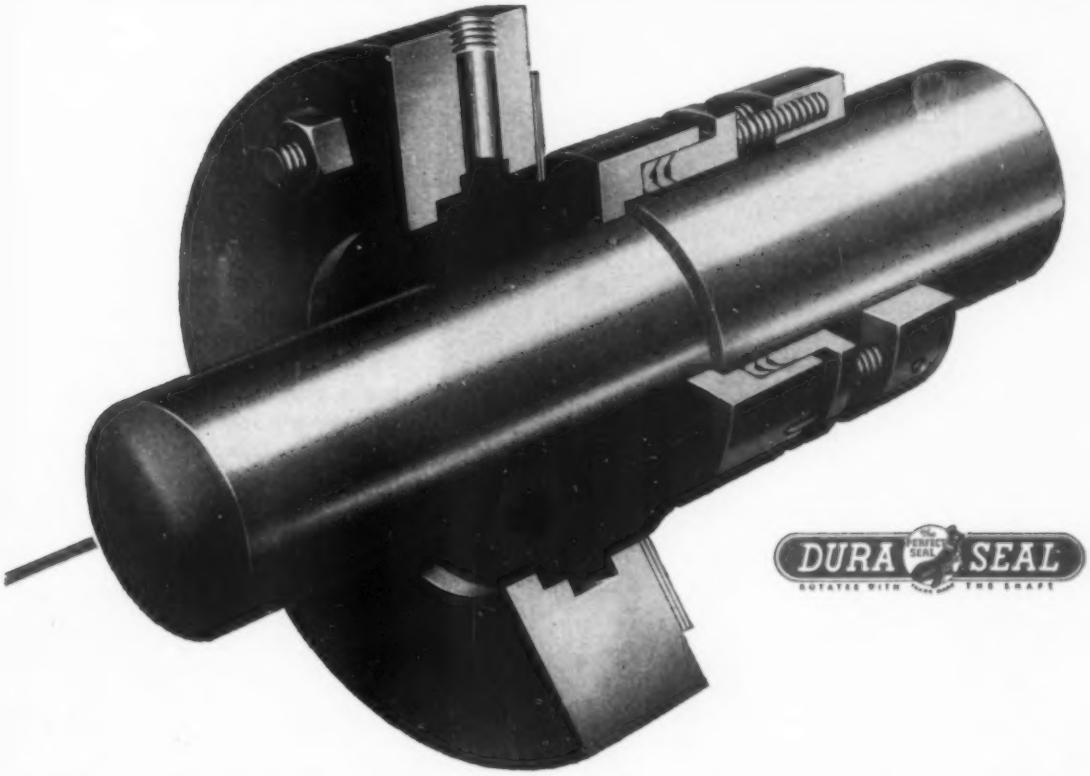
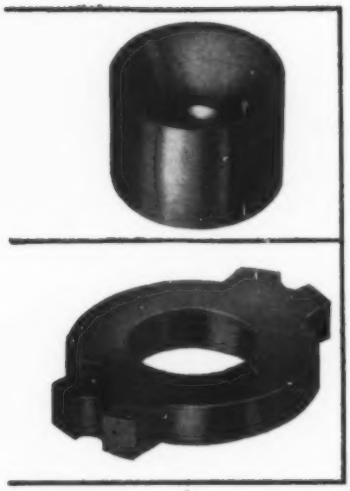
the mechanical seal that rotates with the shaft

Dura Seal mechanical seals, made by Durametallic Corporation of Kalamazoo, Michigan, rotate with the shaft of centrifugal and rotary pumps, autoclaves, blowers, agitators and other rotating equipment to provide a pressure-tight liquid seal. They are made to operate with most any fluid, including highly corrosive acids and alkalies, at temperatures ranging from 80° F. below zero to 400° F. above zero and pressures up to 600 psi. A stationary GRAPHITAR gland insert provides an anti-frictional surface in conjunction with a hard-surfaced rotating unit of the Dura Seal. This fine combination insures tight, trouble-free, long-lasting protection against leakage. GRAPHITAR is ideally suited for this application because it is self-lubricating, chemically inert and highly resistant to wear.

THE UNITED STATES

efficiency of Dura Seal-





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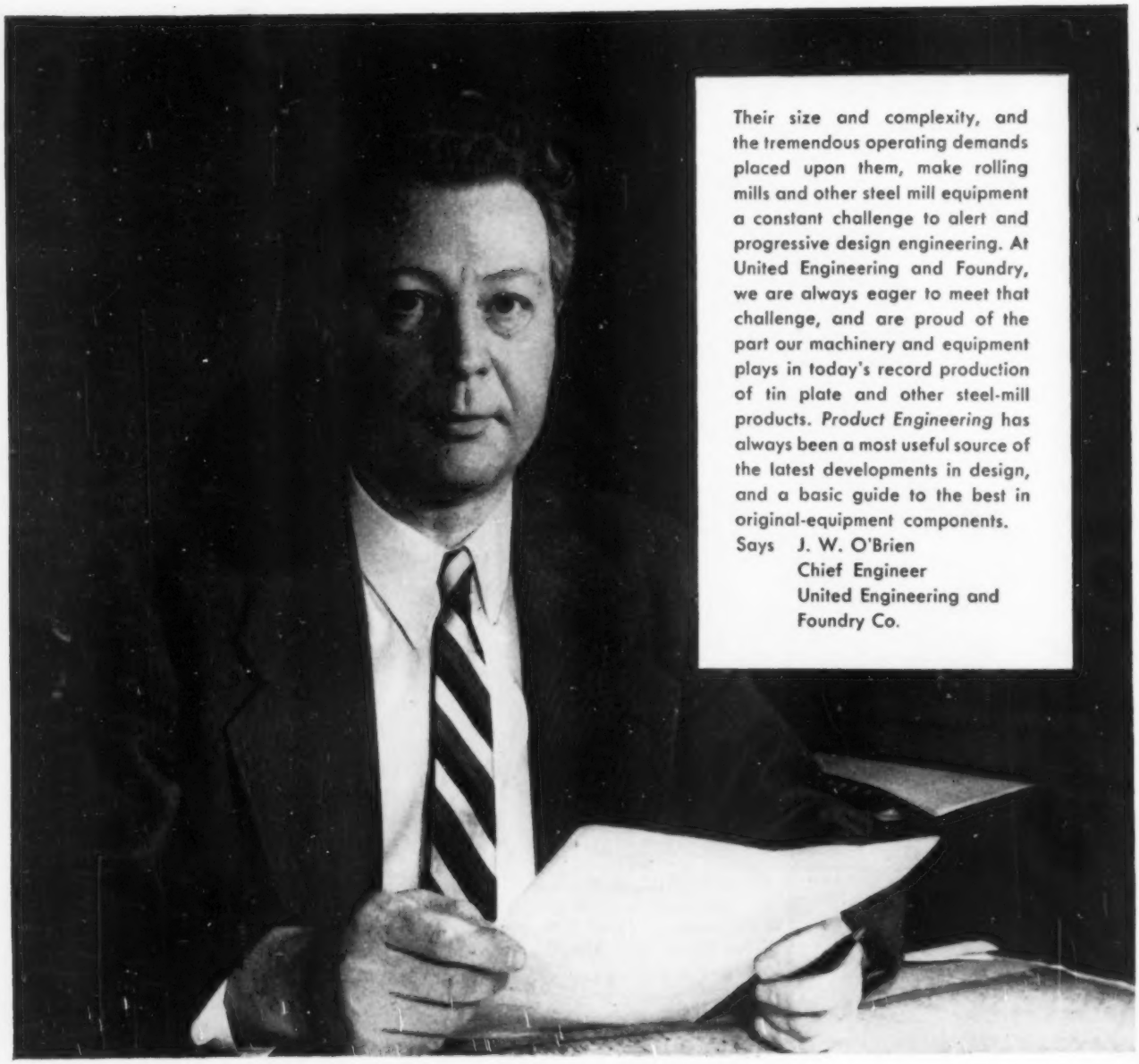

Their size and complexity, and the tremendous operating demands placed upon them, make rolling mills and other steel mill equipment a constant challenge to alert and progressive design engineering. At United Engineering and Foundry, we are always eager to meet that challenge, and are proud of the part our machinery and equipment plays in today's record production of tin plate and other steel-mill products. *Product Engineering* has always been a most useful source of the latest developments in design, and a basic guide to the best in original-equipment components.

Says J. W. O'Brien
Chief Engineer
United Engineering and Foundry Co.

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THE MEN WHO DESIGN

He Designs Steel Mill Equipment

HE READS PRODUCT ENGINEERING

You reach him best, through advertising, in the magazine that is more than ever *No. 1* in the product-design field

Two things have a long-time habit of growing together: the importance of design engineers as the basic force behind industry's progress . . . and the preference these basic industrial buyers have for *Product Engineering.*

Everywhere in industry, the emphasis is on new-product development as the best answer to bigger sales in highly competitive markets. Up 300% since 1940, industry's 1954 investment in new-product development will reach $4-billion in 1954 . . . and the men who read *Product Engineering* will not only spark a major part of this development, but will also exert industry's most important voice in the purchase of $30-billion of original equipment parts, materials, components, and finishes.

There has never been a time when concentrated advertising to the leaders in product design engineering could pay you bigger dividends . . . nor a time when any design publication has offered the high advertising values *Product Engineering* offers now. Our all-paid circulation reached 24,500 in June, and is still climbing upward, as this magazine continues to offer your most important customers more facts, ideas, and inspiration than any other magazine available to them.

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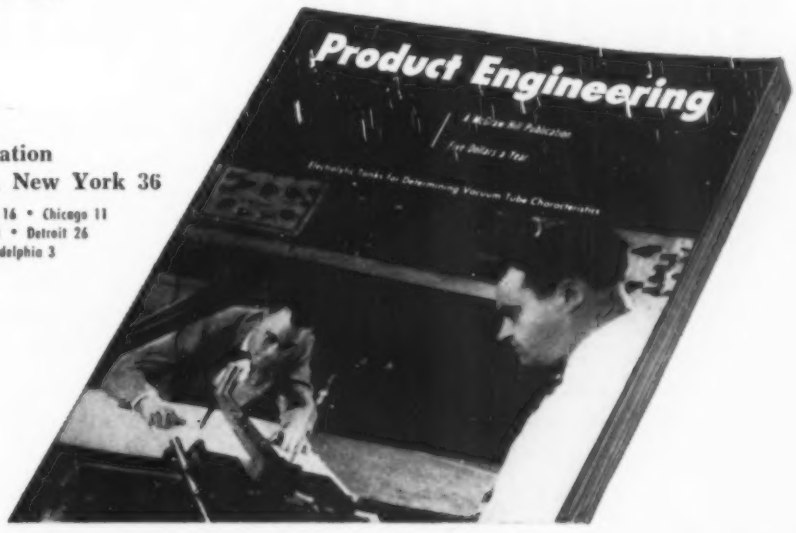
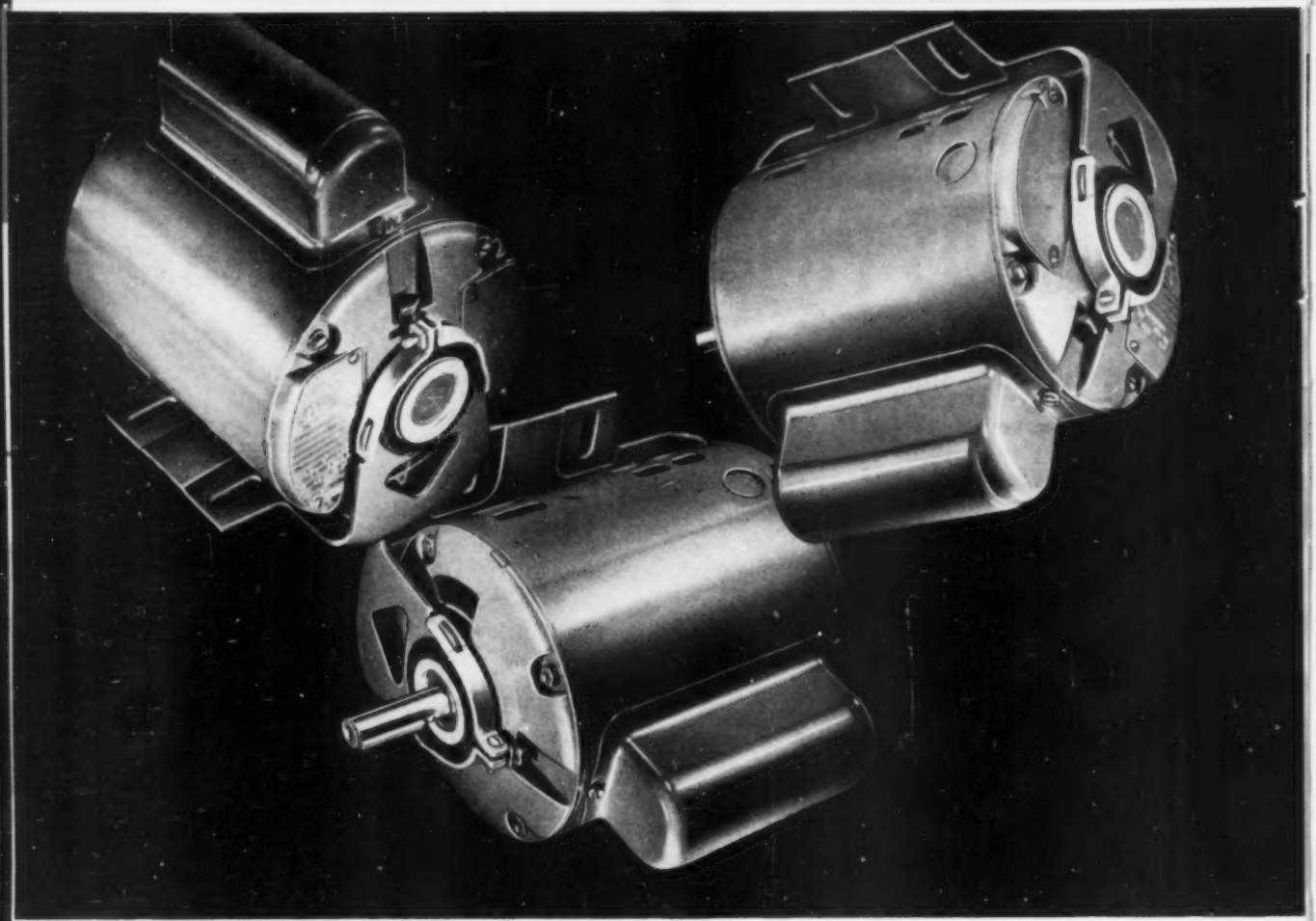


AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING



ALL-ANGLE OPERATION FEATURES of G-E's new fhp motor permit lower cost installation on applications formerly requiring a more expensive motor. Extra large oil reservoir plus features shown at right, give you an all-position motor.

Mount this standard G-E

Lubrication system insures quiet all-angle operation

This new general purpose sleeve-bearing motor gives dependable performance regardless of mounting position. A unique thrust-bearing design permits moderate-thrust loads in any direction and a new lubrication system gives full retention and recirculation of oil.

Brand new "Mylar"* polyester film . . . a *modern* insulation . . . means longer motor life. Full NEMA performance with up to 50% less weight and 40% less size means maximum power in a minimum package . . . reducing your handling and shipping charges.

For more information call nearest G-E Apparatus Sales Office or write Section 702-3 for Bulletin GEA-5567, General Electric Company, Schenectady 5, N. Y.

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You can put your confidence in—

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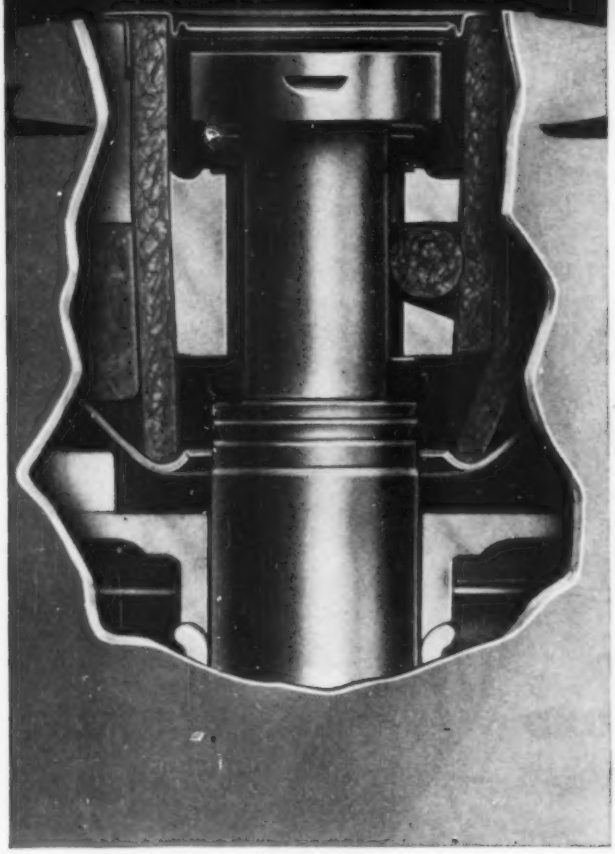
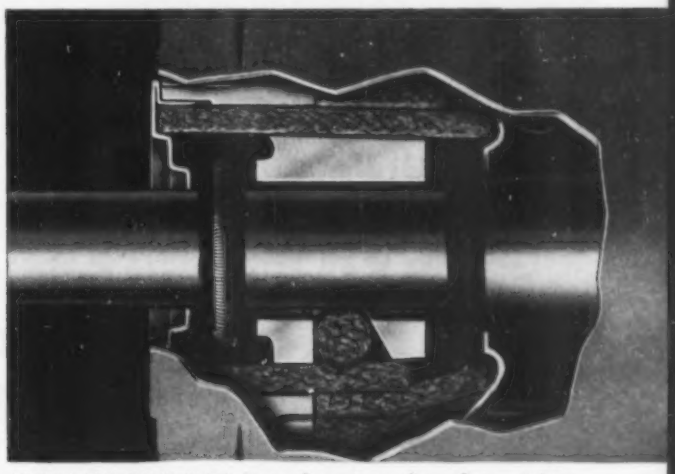


LOCKED-IN THRUST WASHER ASSEMBLY makes it possible for this G-E motor to handle moderate-thrust loads in any direction.

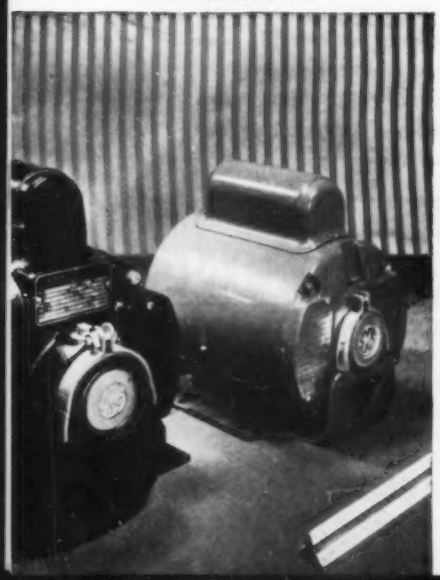
THREE LUBRICATING WICKS evenly lubricate the shaft by picking up the oil and retaining it for redistribution to the shaft.



SHAFT OIL THROWERS instantly return the oil to wicking while spring loaded thrower prevents loss of oil along the shaft.

Fhp motor in any position

SMALLER . . .



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SPECIAL *Chill* CAST BRONZE GEARS

HARDENED AND GROUND STEEL WORMS

Advantages of Philadelphia Worm Gear Reducers

To insure long, dependable service from Philadelphia Worm Reducers, the greatest care and research goes into the selection of materials for the worms and worm gears. The predominant sliding action dictates the use of dissimilar metals to minimize frictional wear.

Philadelphia Worms are of alloy steel with hardened threads. Shaft and threads are smoothly ground and polished after hardening. The result is increased gear life through improved surface finish.

Worm Gears are of high quality chill cast nickel bronze to provide greatest strength, with a low coefficient of friction against the worm.

These and other features of Philadelphia Worm Gear Reducers are explained in detail in our Catalog WG 51 . . . send for a copy.

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Perspectives~ DESIGN AND DEVELOPMENT

UNSCIENTIFIC ENIGMA

Corrosion engineers have launched a new battle against an old enigma. Once again they are trying to disprove the merit of certain devices that are supposed to control scaling or corrosion in water pipes, but which apparently do not operate in any known scientific manner.

Although some of the devices use metals, they should not be confused with the well established principle of fighting electrolytic corrosion by coupling metals in accordance with the galvanic series.

Such gadgets are not new. They have been available, in one form or another ever since it was discovered that impurities in water could form scale and corrode metal. Their fortunes rise and fall as their manufacturers promote them, give them up, get in trouble with the law, or pass out of existence.

BEWARE GADGETS

Currently, use of the gimmicks is on the upswing. At least five different "conditioners" are being promoted in the United States and sold in such quantities that engineering societies have become concerned about possible hazards resulting from dependence on such devices for scaling protection. Earlier this season, corrosion specialists gathered at Wrightsville Beach, N. C., to hear an off-the-record report on the gadgets. This seminar coincided with the issuance of a warning by the Inter Society Corrosion Committee (sponsored by the National Association of Corrosion Engineers). Gist of ISCC's notice: Beware of any device that is not based on understandable scientific principle and which is sold on the basis of testimonials from presumably satisfied customers.

THE DILEMMA

A specialist who has studied and tested all the known water conditioners put the dilemma in a nutshell. Said he: "Of course these things are phony. But try and prove it!" That's why nobody is willing to talk for publication about them.

Several companies, well known for their corrosion studies, have attempted to evaluate anti-scaling gimmicks. So have independent laboratories and government installations—the Navy is constantly being positioned by manufacturers of the "conditioners." To date, nobody has been able to prove *conclusively* that any such device has ever prevented the formation of scale or corrosion.

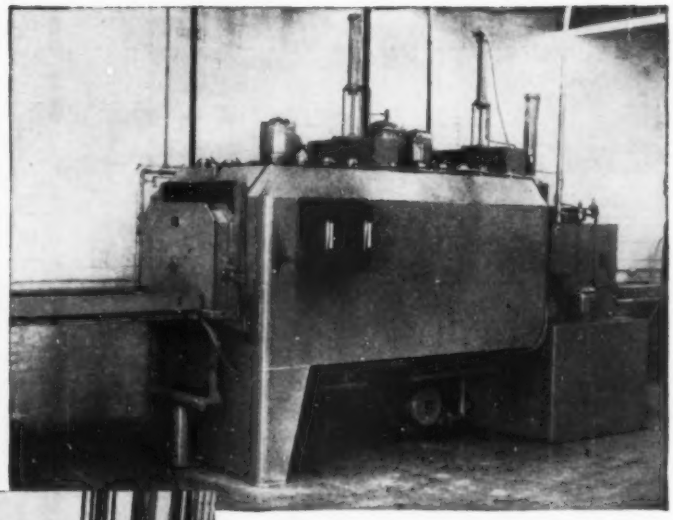
THE PATTERN

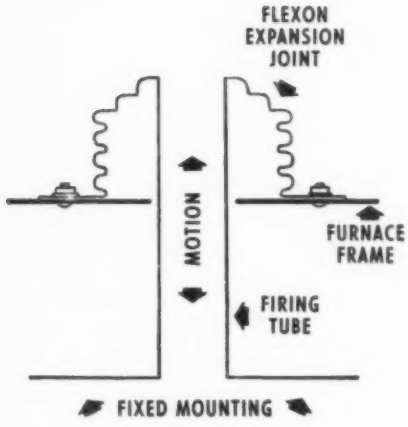
Inventors seem to follow a set pattern when they announce a new anti-scaling gimmick. They rely on semantic mumbo-jumbo to explain how scale formation is prevented. They claim that operation cannot be understood completely or explained in present day terms. In every tested sample "there is no discernible change in the water as it passes through the system."

(Continued on page 125)

Here's how

FLEXON EXPANSION JOINTS solve a difficult motion problem in this heat treating furnace





In the heat treating furnace illustrated above, which is manufactured by Ipsen Industries, Rockford, Ill., the unit is brought to temperature by burning gas in vertical tubes that extend through the furnace. Thermal expansion of these tubes at 1000° F. presented a mounting problem that was solved by attaching the free end of the tube to a FLEXON Expansion Joint, which in turn is mounted on the furnace frame as shown in the drawing. To combat the high temperatures and corrosive conditions, the expansion joints are fabricated from No. 321 stainless steel.

This is the type of problem that is a specialty of Flexonics Corporation. Whenever you have a connection problem, whether it be caused by expansion, flexation or vibration, let Flexonics know-how solve it for you.

Flexonics Catalog No. 128 gives full information on Flexon Expansion Joints and other motion control problems. See also the Flexonics catalog in Sweet's.

Flexonics *Corporation*

EXPANSION JOINT DIVISION
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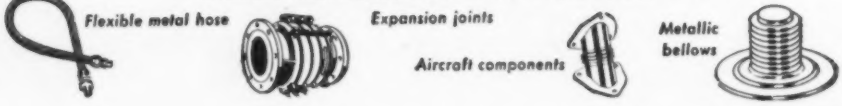
Flexon identifies products of Flexonics Corporation that have served industry for over 50 years.



BLACK MAGIC

Some of the devices might even be based on black magic if their advertising is correct. For instance, one relies on a cast iron bar for its unique properties, a bar that is "activated" when the inventor throws a secret powder into the melt at the foundry. Another uses a cartridge containing a powder that "defies analysis." Others depend on unusual effects resulting from zinc and copper put together in strange geometric configurations.

Some of them are connective devices, others go inside pipes. Some are sold, others are only leased.

Installation instructions, for one of the devices, state that the water system must be shut down and cleaned thoroughly before the conditioner is inserted. Operating personnel say that makes the device have some value even if it doesn't control scale formation—its installation gives them a chance to chip out deposits by conventional methods. And that never hurt any system.

BIG BUSINESS

Despite the frequent charges of quackery raised against them, the anti-scaling water conditioners are big business. One of the current best sellers costs from 50 to 3,000 dollars, depending on size. The manufacturer claims to have sold 100,000. Observers think he's being modest; the correct figure is probably closer to 150,000.

Most surprising is the number of big industrial names that appear on customer lists of the gadgeteers. Why do they buy them?—because of the testimonials. Every manufacturer of the gadgets has a huge supply of letters; each states that the device definitely prevented scaling—according to a satisfied user.

TESTIMONIALS

Careful examination of such praiseworthy letters shows two significant facts: 1) frequently, the customer is a small, unheard of organization. Experts think the letters might have been written in return for some favor. 2)When the user is a big industrial name, the testimonial is often signed by a person with no technical training, in a minor position, having little responsibility in the company.

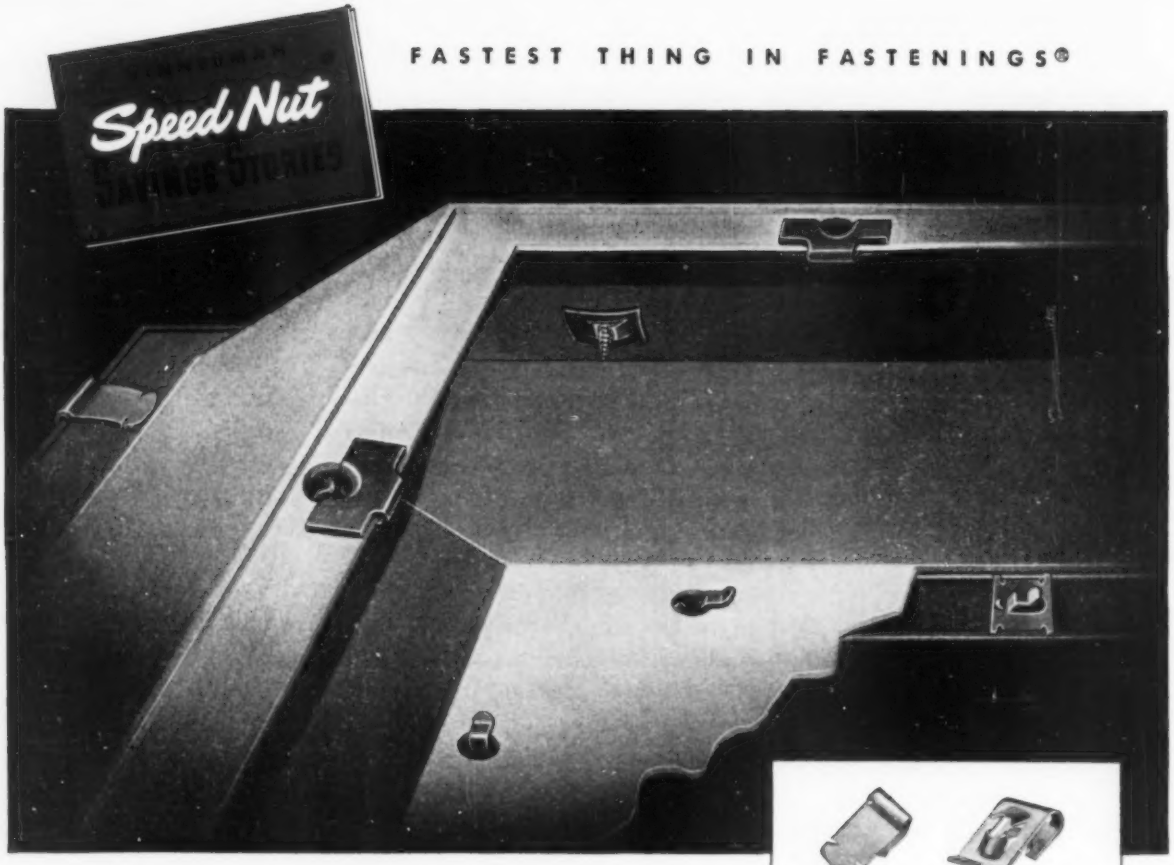
Psychologists say there's one other reason for the testimonials: Nobody likes to admit that they've been fooled. So once they buy a gadget, they'll defend their judgment by supporting the conditioner's operation.

PROMOTION

Unscientific water conditioners are generally sold by specially franchised distributors who do most of the promoting. Most magazines will not accept space advertising from them. In addition, the manufacturers are reluctant to send their bulletins through the mail, lest they become embroiled with postal authorities and the fraud laws. That leaves it up to distributor salesmen to spread the news by word of mouth.

At present, none of the gimmicks is in trouble with the law. Federal Trade Commission is currently investigating one manufacturer who claims FTC was set on him by a trade association with an axe to grind. However, he's confident the agency will not prosecute him; he's already passed an exhaustive study by a local district attorney's office. And meanwhile, the new orders keep rolling in.

FASTEST THING IN FASTENINGS®

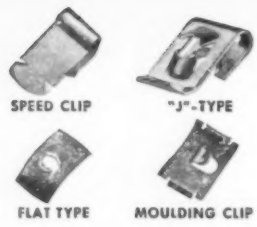


Plastic Sign Maker "Signs Up"
48% SPEED NUT® Savings!

Everbrite Electric Signs, Inc., Milwaukee, Wisconsin, has found the "sign of savings" in Tinnerman SPEED NUT brand fasteners. Designers at Everbrite specified 4 different types of SPEED NUTS in the production of these smart plastic signs. The result was an estimated savings of 48% in assembly time, cost of materials, and materials handling!

SPEED NUT applications in plastics present unlimited money-saving opportunities. Production advantages like these are the reasons . . . SPEED NUTS eliminate costly threaded inserts, are self-retaining and vibration-proof, make faster, easier "blind" attachments, permit greater design flexibility, harness cold-flow tendencies, eliminate heat sealing, and minimize assembly damage!

For cost-saving details on the use of SPEED NUTS in plastics, call in your Tinnerman representative.



These four SPEED NUTS perform important time-saving functions in the assembly of the Everbrite sign shown in cutaway illustration above. Made of highest quality spring steel, SPEED NUT fasteners are lightweight, self-retaining and vibration-proof.

Send for your "SAVINGS STORIES" booklet of interesting SPEED NUT savings to industry. Write today:

TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A. – 7 rue Henri Barbusse, Levallois (Seine).

Conflict and Dissatisfaction

THE PEOPLES of a nation must be determined, willing to work, and willing to accept whatever hardships befall their lot if they expect to accumulate and keep material wealth and maintain high productivity. The resulting abundant peaceful living does not develop such attributes. To the contrary, it tends to deteriorate the people. Only continual conflict can make and keep people strong, determined, and willing to work. That's why continual conflict is one of the two essentials for great "national prosperity."

Usually, conflict is in the form of war. It may also be a battle against natural elements. It might be the struggle to keep the nation militarily strong enough to discourage its enemies. Or it might be the struggle and sacrifices required to withstand foreign competition. Whatever the form may be, the nation must be facing eternal conflict in order to develop and maintain in its people the willingness and ability to create, produce and build. Strength is developed by adversity, not by affluence.

The other essential for a continuing prosperity is dissatisfaction. It is the key to broadening markets that are necessary for the support of mass production. High rate of production cannot continue very long unless the goods and services produced are distributed. Only by making the owners of products dissatisfied with them is it possible to have a continuing ready market for the products that must be manufactured in great quantities to make possible a low selling price that further broadens the market.

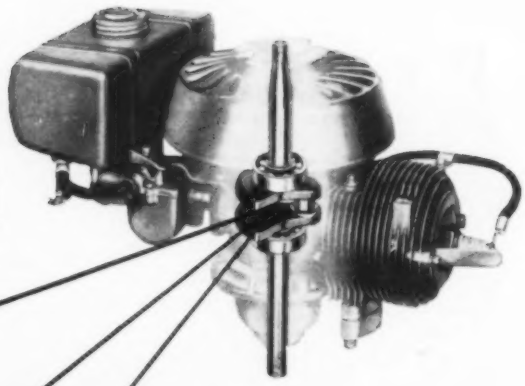
Dissatisfaction with the model owned is created by the availability of a new and better design. Thus begins the chain reaction: A new model is bought by trading in the old one which is subsequently sold for another trade-in, and so on—until those on the lowest economic level are the proud possessors of an auto, radio, television, or whatever the product may be. Dissatisfaction spins the wheels of commerce.

In all of this, the design engineer plays a crucial part. Through his inventive ability, ingenuity and resourcefulness he develops the military equipment to deter or defeat the enemy, the machines and devices to protect the people against the natural elements, the machinery of production to save labor, the instruments of communication, and the vehicles of transportation. And of equal importance, it is the design engineer on whom we depend for new products and new models that will stir up tremendous dissatisfaction with things as they are.

Conflict and dissatisfaction—the two essentials for national prosperity. The first breeds national strength, willingness to sacrifice, and determination. The second, stimulated by the work of the design engineers, causes trading and commerce. That makes jobs for all, raises standards of living—and weakens resistance to the forces that cause decay.

George F. Jordenholt

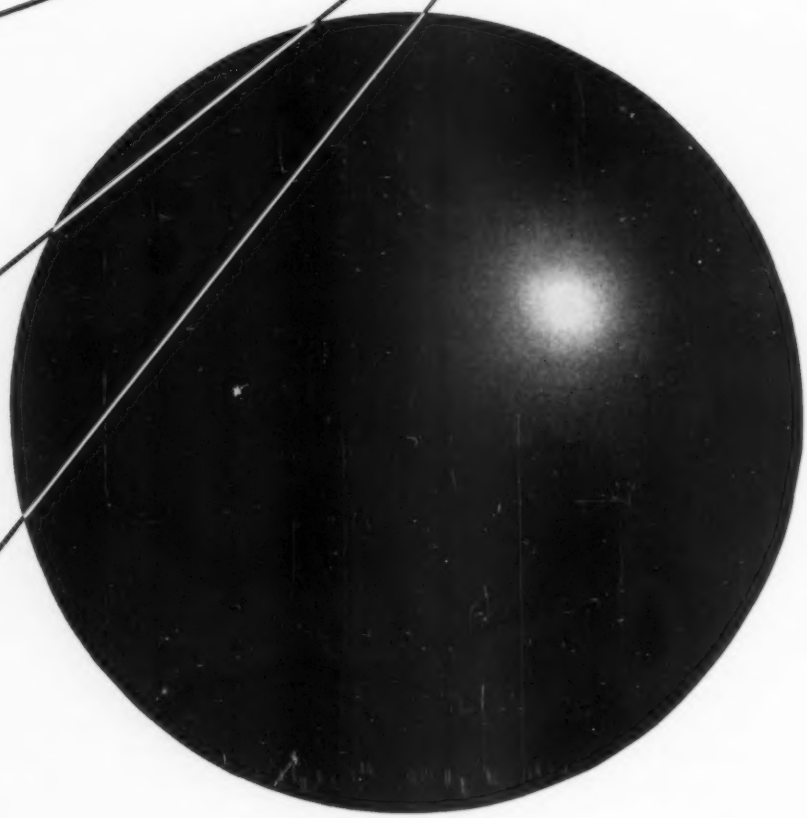
This Lightweight's a Heavy Worker!



Yard work is really fun with a Lightweight-powered midget tractor.

Cutting a tree is as easy as falling off a log . . . with Lightweight power.

Mowing a lawn is light work with 12-pound Lightweight gas engine.



Jack-of-all-trades . . . master of *every* one—that's Power Products' 12-pound Lightweight Engine! This versatile power plant has proved itself in scores of applications where light weight is a factor. Its makers credit much of its success to the New Departure ball bearings which support the crankshaft. *New Departures made 15 major improvements possible* . . . such as higher power, lower upkeep, *much* longer life!

In fact, New Departures can improve *any* product that demands low-friction, rigidly accurate support of moving parts. In everything from heavy industrial to sensitive instrument applications, American business can call on New Departure's research, engineering and manufacturing facilities —most extensive in the ball bearing industry.

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE

BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

Also Makers of the Famous New Departure Coaster Brake

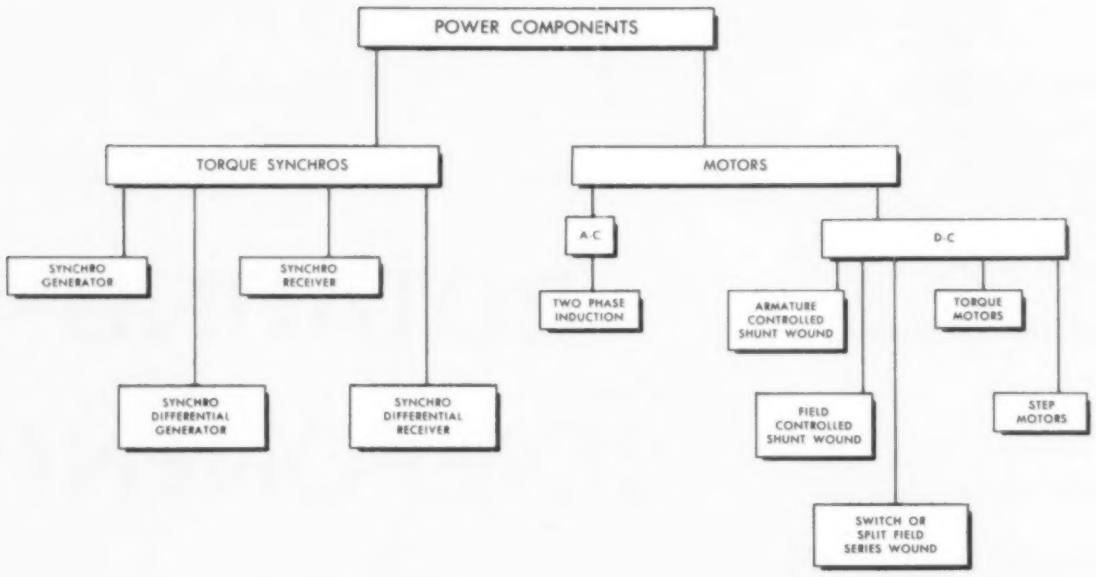
- Linear Resistance Potentiometers
- Nonlinear Function Generators
- Induction Components
- Synchros
- Servo Motors
- Speed Measuring Devices
- Miscellaneous Control Components
- Typical Application Circuits

ROTATING COMPONENTS FOR AUTOMATIC CONTROL

SIDNEY DAVIS*
Arma Corp., New York

**The author recently became affiliated with Servomechanisms, Inc., New York as Chief Development Engineer of their Components Division.*

PRO[illegible] NOVEMBER 1953



CHARACTERISTICS OF COMPONENTS FOR CLOSED LOOP SYSTEMS

Accuracy—Low power transducing and computing elements must be as accurate as system being controlled. High power equipment need not be precise and can vary with temperature and aging. However, high gain and fast response must be maintained.

Reliability—The novelty of many of the components and lack of experience with them have complicated the reliability criterion; however, exacting military standards have been met and can be carried over into industry.

Quality — Low power components must be free of stray residual signals since high gain amplifiers can be saturated by false signals of the same order of magnitude as the error to be corrected. Auxiliary equipment such as gears and bearings must be smooth running and free from backlash for stable performance.

Range of Variation—Resolution and positive setting must be good over a wide range of adjustment. Equipment must be capable of standing severe intermittent overloads and rapid reversals. Low load operation, as when following a slowly varying input, makes the intermittent rating important for equipment economy.

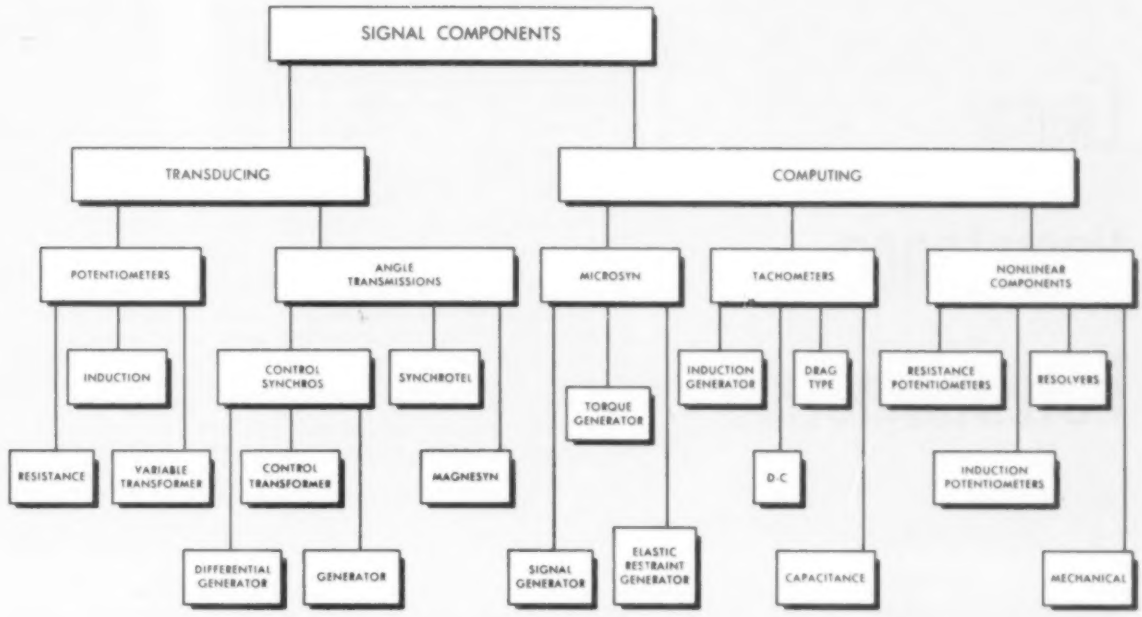
Cost—Low power elements are many times as expensive as comparable devices not intended for closed loop operation. Although some cost distinction will probably always exist, mass production and competition are reducing prices. The cost differential between closed and open loop high power devices is not as great.

ROTATING COMPONENTS are used as the transducing, computing and power elements in most electromechanical closed loop control systems because of:

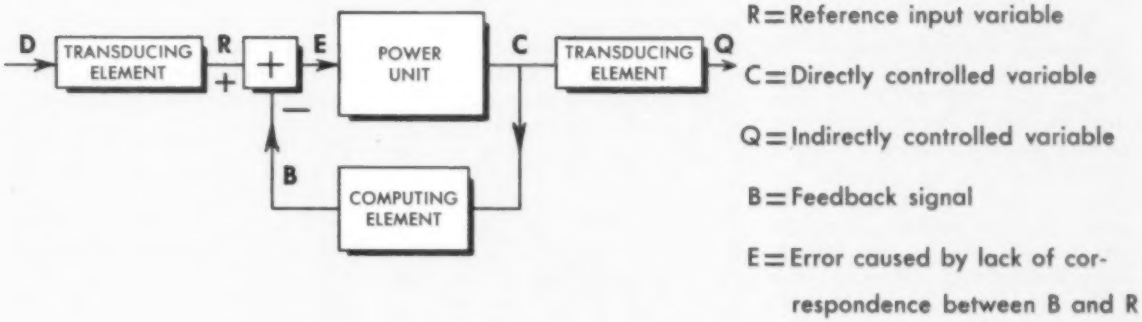
1. *Unlimited motion.* This means small physical size and high resolution.
2. *Angular input or output.* Most measured or controlled quantities can easily be converted into proportional angular positions.
3. *Geared output.* Scaling and inertia matching can be accomplished by selecting the proper gear ratio.
4. *Symmetrical construction.* This inherently results in a sturdy and compact design.
5. *Mass production.* The cylindrical shape of parts lends itself to high quality and high quantity production.
6. *Continuous operation.* There are no limit stops, reversals or discontinuities such as encountered in linear motion devices. This property also permits high speed operation.
7. *Magnetic structure.* Satisfactory methods have been developed for using circular a-c magnetic structures that can be laminated along the lines of flux. Further, in noncircular a-c devices, fringing difficulties are encountered.

For convenience, the various types of rotating control components have been classified as follows: linear resistance potentiometers, nonlinear function generators, induction components, synchros, servo motors, speed measuring devices and miscellaneous control components. The accompanying chart points out the function of each of these categories in a closed loop system. Since there is often no distinct line of demarcation, this cannot be a rigid designation but depends on the design.

The characteristics required by the individual components depend on their location and function in a closed control loop. In feedback systems, a reference value of a controlled variable is compared with the measured value of that variable. The difference is the system error, which is amplified and directed to correct the measured value to secure correspondence with the desired reference value. This correction



GENERALIZED SCHEMATIC OF FEEDBACK CONTROL SYSTEM



will continue until the error approaches zero. Components are required that will measure the input (reference) and output (actual) values and transform them to a common unit of measure for purposes of comparison. The low power error signal is amplified and drives the output to a null position. The output of the amplifier can range from a few milliwatts to many horsepower, depending on the power required to force the controlled variable to rapidly follow the reference.

Thus, a feedback system consists of a set of precise, low power transducing and computing devices, and a high power controlled prime mover that converts the amplified error into a correcting force. This distinction is important: it is difficult to obtain both high power level and precision in the same component.

In closed loop systems, any time lag between a change in input and the application of a correcting force to the output tends to introduce instability. With a varying input, this delay can cause the correction to be applied at the wrong time or in the wrong direction, either of which can result in an oscillatory response of the output. Thus, a special requirement of these components is a high speed of response. Energy storage elements, such as springs, inertias, capacitors and inductors, should be reduced to a minimum.

The selection of the low power elements is based on the most convenient over-all arrangement for converting all signals to a common denominator with a minimum number of transducers. Accuracy, dynamic response and stability are also important factors.

High power component selection involves a study of the power requirements of the load, the rate of change and acceleration of the input variable, the allowable error in correspondence, and system dynamics.

The power components discussed in the following sections are limited to outputs of under 100 watts. The precision signal components are applicable to systems of any size.

Linear Resistance Potentiometers

TABLE I—FACTORS TO CONSIDER IN POTENTIOMETER SELECTION

Electrical Suitability

a. Linearity as required by the application.
b. Tolerance on total resistance and shaft angle.
c. Methods of user trimming for maximum interchangeability in installation.
d. Resolution error and its effect on servo stability and wear.
e. Sufficient electrical insulation strength.
f. Freedom from stray capacitive and inductive effects.
g. Generation of undesirable radio interference.

Mechanical Suitability

a. Proper choice from wide range of available types.
b. Adequate life to meet anticipated performance cycle.
c. Adaptability to environmental conditions: temperature, humidity.
d. Ability to withstand vibration without excessive contact bounce.
e. Precision of mounting surface and shaft extension.
f. Provision for easy zeroing and calibration.
g. Acceptable starting friction.

A POTENTIOMETER develops an output voltage proportional to the product of an input voltage and some function of a mechanical displacement. When the function of displacement is linear, the potentiometer is defined as linear.

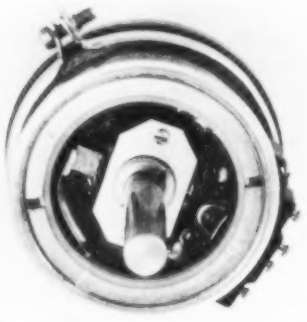
Resistance potentiometers derive their mechanically variable output by the motion of a wiper arm on a resistance element whose terminals receive electrical excitation. The correspondence between mechanical motion and output voltage facilitates the conversion between electrical and mechanical variables. The linear resistance potentiometer is widely used for measurement, signal transforming, computation and comparison. Many types are available for control applications. Some of these are discussed below.

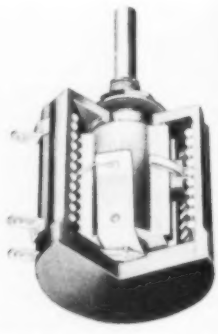
Single Turn Potentiometers

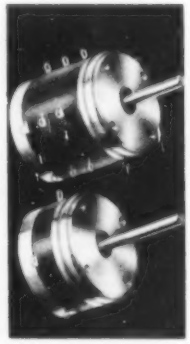
Single turn potentiometers, Fig. 1, usually have a wiper rotation of less than 360 degrees, although continuous rotation types are available. Accuracy is limited by geometric precision and improves with increasing diameter. Resolution, or the step nature of the output as the wiper moves from wire to wire along the resistance element, is limited by the fineness of the wire. This in turn determines the total number of resistance element turns. Wire fineness is also limited by its resistance to corrosion and mechanical strength requirements. Resolution is important in automatic control systems where the pot wiper may alternate rapidly between two adjacent positions as it interpolates the output. This oscillation results in wear on both the potentiometer and the complete system, and in the generation of electrical and acoustical noise.

Multi-Turn Potentiometers

To increase accuracy and obtain finer resolution, many manufacturers have developed multi-turn potentiometers in which the coiled resistance element is helically wound around the axis of the rotating input shaft, Fig. 2. As the wiper arm rotates it is driven axially by a screw arrangement on the shaft. Aside from increased cost and size of the multi-turn potentiometer, it suffers from certain functional disadvantages. The increased angle of shaft rotation requires operation at a high gear ratio with respect to its drive motor, thereby contributing friction and inertia to the







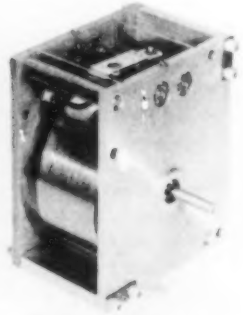


Fig. 1—Interior view of a Fairchild Type 756, single turn unit including brush arm assembly, mandrel type resistance element, shaft and internal connections. Units such as these find the widest application. Fig. 2—Cutaway of Model A, 10-turn potentiometer manufactured by the Helipot Corporation. Units of this type are available in accuracies down to 0.025 percent. Fig. 3—Micromax Type 105 carbon film potentiometer. This unit is one of the smallest available packaged precision potentiometers of infinite resolution. Two or more of these components can be ganged without loss of accuracy. Fig. 4—Precision linear slide wire potentiometer manufactured by the Ford Instrument Co. It is primarily for low voltage, high accuracy measurements in circuits requiring a low impedance component. The contactor is rotated at a random rate by a gear assembly to insure freedom from wear patterns.

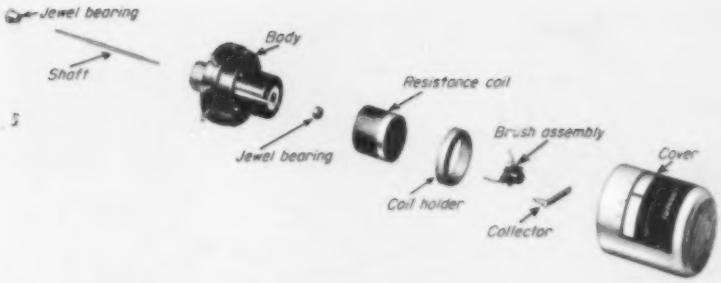
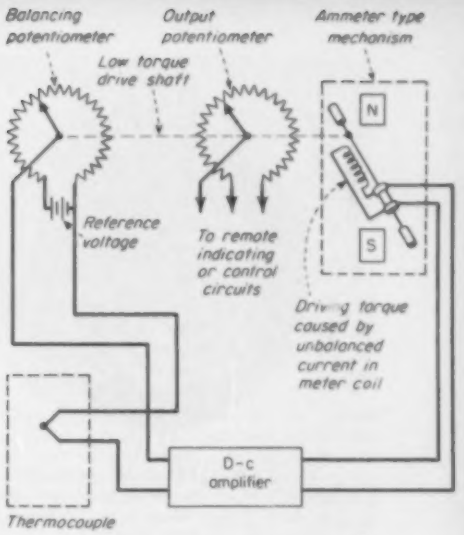


Fig. 5—Exploded view of Giannini Microtorque potentiometer. Note the slender shaft required for use with the jewel bearings. Care must be taken to avoid shaft strains from excessive overhung loads. Fig. 6—Ganged, low torque potentiometers in a temperature control circuit. The output potentiometer transmits data to external circuits for control or indicator operation. The isolation of the output potentiometer permits freedom in the selection of voltage, frequency and resistance. The unit is compact, fast acting and has wide application in the field of data conversion or transmission.



system. The higher operating speed also causes a multiplication of the wear factor. To balance this, it is possible to reduce the precision of the driving gears. In spite of these limitations, its improved accuracy and resolution are resulting in wide application in many types of control systems.

Precision Composition and Carbon Film Potentiometers

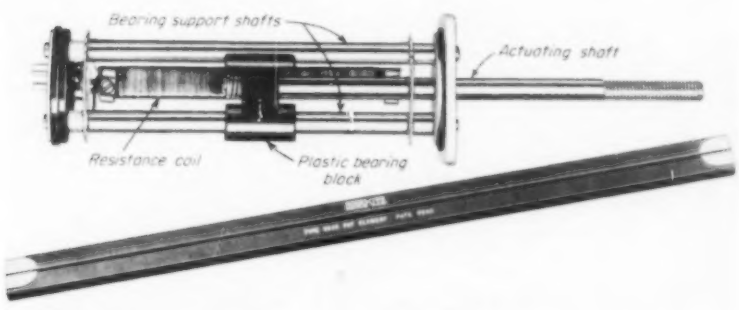
Single turn composition and carbon film component with accuracies of ½ percent and better are available for use in instrumentation, Fig. 3. The composition coating on a rigid surface gives infinite resolution. The noise usually generated in carbon film potentiometers, once a serious limitation, seems to be under control. One manufacturer deposits the composition material on a plastic base designed by the user, while another has tapped linear and nonlinear carbon film potentiometers for applications such as sensing elements in gyros and telemetering devices. Component life is adequate for general instrumentation purposes.

Slide Wire Potentiometers

Both single and multi-turn potentiometers, Fig. 4, based on slide wire action and having infinite resolution, are available as precision elements. These components are characterized by smooth, stepless operation, low noise level, long life, and low starting torque. Potentiometers of this type can be used to reduce chatter in servo systems. Resistance values of 2,500 ohms are available in a ten turn Giannini potentiometer. This value is high for the slide wire type construction.

Low Torque Potentiometers

Potentiometers are available for applications having shaft torque requirements in the order of 0.003 oz-in., Fig. 5. These are useful where the displacement of a mechanical transducer (for example: pressure diaphragms, altimeters and dial indicators) must be converted to an electrical signal with no intermediate force amplification. Jewel bearings and accurately adjusted precious metal brush elements are required to meet the torque specification. In applications where the resistance is low and large sized wire must be used for the resistance element, it is neces-



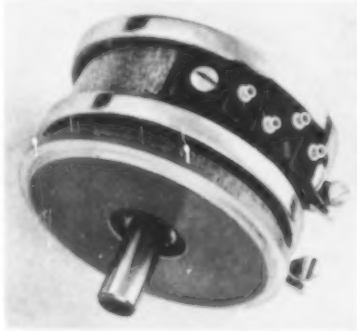


Fig. 7—The Giannini linear motion potentiometer, (A), is useful in applications requiring straight line motion to voltage conversion. It is available in accuracies down to ½ percent of maximum output. Infinite rotation of the input shaft is possible. Mechanical guides assure positive contact seating, free from backlash. The Markite potentiometer, (B), is about 1 percent accurate with an infinite resolution conducting plastic resistance element. This unit is noted for operational reliability and long life. The toughness and wear and corrosion resistance of the plastic track prevents random failures and the uncertainty of life of the wire wound units. Fig. 8—This unit, Fairchild Type 756, is typical of the precision synchro type mounting and shaft design required in control potentiometers that must be gear-coupled to other components. Most standard potentiometers are available with these features.

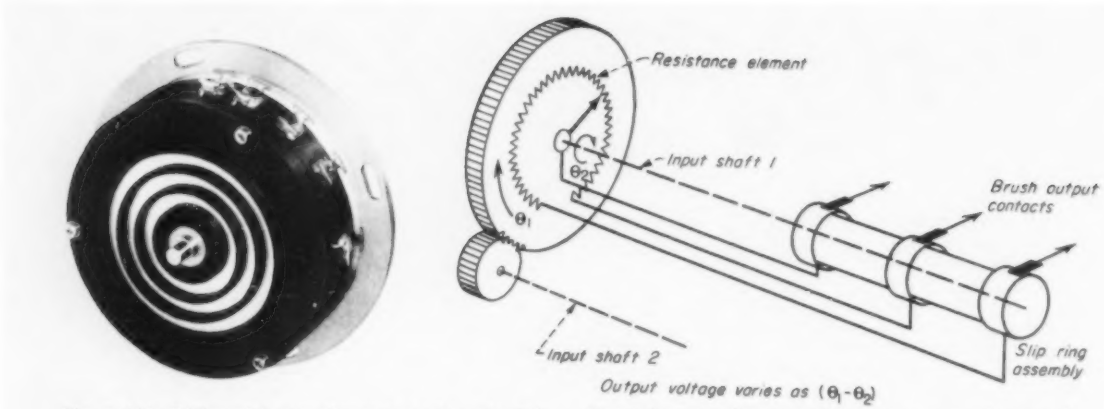


Fig. 9 (A)—Differential potentiometers, such as the Fairchild D-C-P, are useful when a voltage must be developed that is proportional to the difference between two shaft positions. Typical applications include servomechanisms, instrument controls, computing devices and analyzing units. (B)—Schematic diagram of this type potentiometer in which the output voltage corresponds to the sum or difference in position of the two input shafts. In actual units the entire differential potentiometer is mounted on one of the rotating elements to give one input position.

sary to increase the torque requirement to 0.004 to 0.006 oz-in. Low torque potentiometers can be used to measure strain without appreciably loading the strained element. They are available with taps in continuous rotation types to convert to a-c or d-c synchro voltages.

The Electro-Mec Laboratories have designed a self-balancing circuit, Fig. 6, based on the use of low torque potentiometers. This does not require the usual servo motor drive. The amplified unbalance voltage is directly applied to an ammeter-type mechanism that develops sufficient torque to drive the potentiometer.

Linear Motion Potentiometers

Where mechanical motion is available as translation rather than rotation, a linear motion potentiometer, Fig. 7, can be used instead of a rotary motion potentiometer with a rack and pinion or other motion converting device. The linear motion potentiometer reduces friction and size, and gives increased accuracy in this application. These components can be supplied as dual units where parallel isolated channels are required. They are useful for measuring vibration and the rectilinear motions of complex linkages, and can be obtained with resolution as low as 0.001 in. Many special types are available with, for example, spring return, double shaft extensions, and rounded shaft ends for operation with cams or other sliding devices. The Technology Instrument offers a line of these units with active strokes of 1 to 15 inches.

High Torque Potentiometers

High torque components are usually used as trimming or adjusting elements. Stability, insensitivity to vibration, and miniaturization are their most important qualities, while linearity and life have less significance. They are available with either linear or rotary motion inputs. High torque can be derived by applying spring pressure axially along the shaft. They have screw driver adjustment elements, and are used in systems requiring "in the field" adjustment, such as generator voltage regulators and motor speed governors.

Miscellaneous Types

The inherent simplicity of the resistance potentiometer has resulted in the development of a large number of spe-

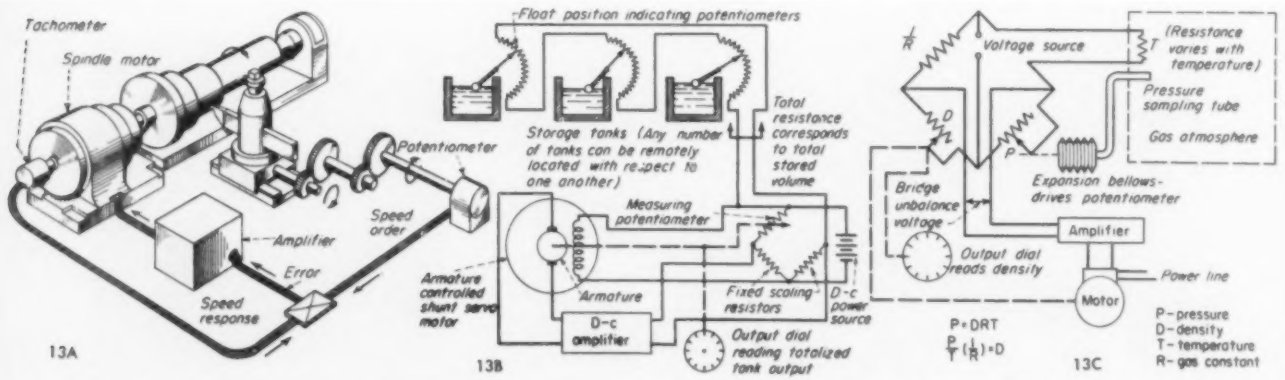


Fig. 13—Industrial Applications of Potentiometers. (A)—*Control.* For maximum cutting efficiency, the surface cutting speed should be maintained constant as the work outside diameter is reduced. Special potentiometers are available for use with cam drive, or standard potentiometers and gearing can be used (as shown) for controlling the speed of the spindle motor in accordance with the cross-feed location. (B)—*Computation—Addition.* Schematic of method for totalizing the contents of storage tanks based on the use of potentiometers. The total resistance of the float potentiometers is balanced by the measuring potentiometer. The measuring unit and output dial are actuated by the servo motor which assumes a position proportional to stored volume. A poorly regulated power source, or variations in d-c motor performance has little influence on accuracy. (C)—*Computation—Division.* Adaptation of an air density unit manufactured by the Kollsman Instrument Corporation for aircraft applications. As shown here, pressure and temperature variations affect resistors *T* and *P* in such a manner that the position of potentiometer *D* is proportional to gas density. The bridge unbalance voltage actuates the motor through the amplifier to set *D* in the proper position.

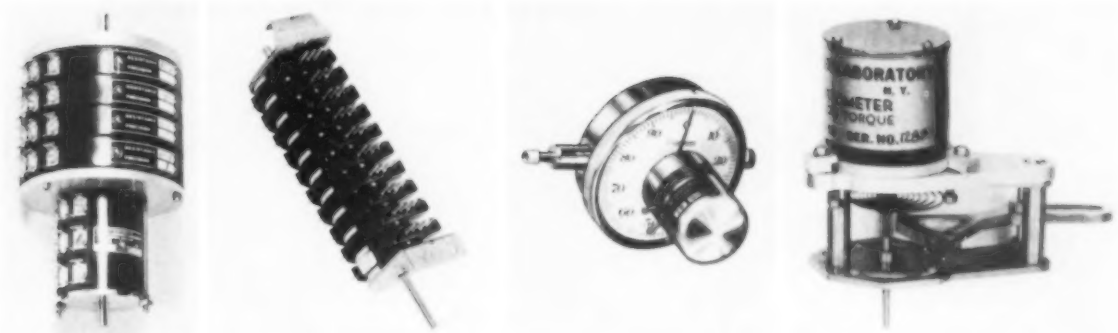


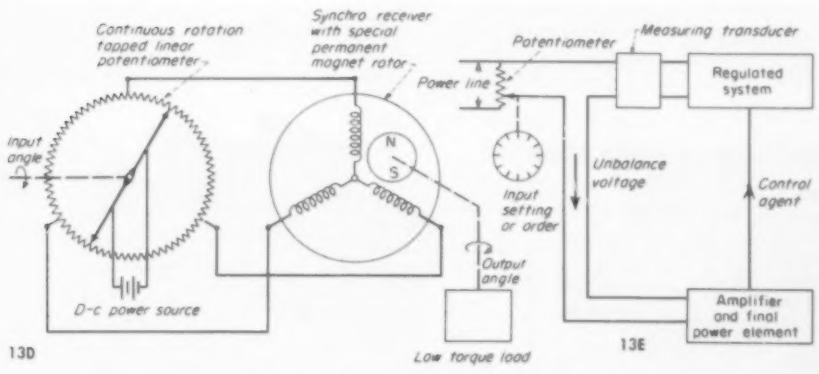
Fig. 10 (A)—The variety of ganging arrangements of standard potentiometers is illustrated by the Fairchild four ganged linear unit combined with a three ganged nonlinear unit. Ganging results in minimum gearing, compact assembly, and simplicity of adjustment. (B)—Fairchild Type P-746 assembly of packaged plug-in components. These units aid in simplified maintenance and ease of assembly. Mechanical locking elements insure error-free alignment in the field. Fig. 11—Potentiometers in indicating and control subassemblies. (A)—Giannini Microtorque potentiometer mounted on a conventional dial indicator for the remote indication of the dial pointer position. This assembly can be used in such applications as automatic inspection and thickness control. Because of the low torque required by the potentiometer, little error is introduced by the external mechanical loading on the pointer. (B)—Standard Bourdon type pressure gage linkage mechanism with an Electro-Mec low torque potentiometer mounted on the gage pointer shaft. The linkage and mechanism have a common shaft. This can be used in a pressure indicating device.

cial types. Mountings vary from the direct installation of the wiper arm and resistance element as separate parts in the user's equipment, to precision mountings resembling those of the synchros, resolvers, motors, and other components of electromechanical computers, Fig. 8. Differential potentiometers, Fig. 9, effectively combining a mechanical differential gear and a linear or nonlinear potentiometer, are useful in servo systems. Units may be ganged permanently by the manufacturer, Fig. 10 (A), or assembled as plug-in units by the user, Fig. 10 (B). At least one manufacturer provides screw driver adjustments to permit phasing ganged potentiometers where accurate zero correspondence is required. Potentiometers are frequently designed directly into subassemblies for convenience and miniaturization, Fig. 11. Multi-turn components are available with special dials, Fig. 12, to show not only shaft angle, but also which turn of the potentiometer is being contacted. These give a semi-digital reading and can be used as the input element to many types of regulating and indicating systems.

A recent potentiometer development by Servomechanisms, Inc. is based on the use of a metallized film resistance element. Potentiometers of this type have infinite resolution, require low driving torque, can be made in a wide range of resistances, and are capable of long, stable operation at temperatures above 100 Centigrade.

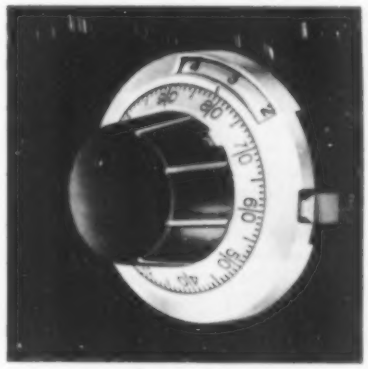
A large variety of taps, resistance, shaft extensions, stops, and tapped continuous rotation units give a wide latitude to potentiometer applications. Components are available that will withstand most environmental conditions: hermetically sealed, corrosion resistant elements; dust proof, moisture proof, units capable of operating satisfactorily at 500 F; and high voltage units that will withstand high potentials to ground. Most linear potentiometers are available in miniature versions.

Present specifications for life generally call for about one million cycles of operation at speeds no greater than several hundred rpm. This is an unimportant limit for many applications, but in some feedback control systems it is a serious restriction. New alloys and wiper designs are expected to multiply potentiometer life by ten or more.



This illustrates the division of two variables by the use of potentiometers. (D)—*Data Transmission.* This circuit shows a convenient arrangement for driving low torque loads such as dials and pointers. The synchro receiver will follow the input motion of the continuous rotation potentiometer. This system is compact, efficient and reliable. (E)—*Regulation.* Generalized schematic of circuits used for the regulation of speed, temperature, flow rate, and many other process variables. The regulated system is synchronized with the input order as a result of the amplification of the error or unbalance voltage. The power element regulates the system until the output of the measuring transducer and input order are equal. This is typical of many circuits using potentiometers as regulating system transducers.

Fig. 12—Model RA Duodial manufactured by Helipot Corporation, used to indicate the position of the slider on a ten-turn precision potentiometer. The outer dial shows the turn on which the slider rests; the inner dial shows the percentage of total slider travel on the individual turn.



Nonlinear Function Generation

IN CONTROL SYSTEMS it is often necessary to develop complex conversions of one or more nonlinear variables. While the linear resistance potentiometer is a versatile component, it cannot be used by itself in these applications since it is only a proportional conversion device between electrical and mechanical data. Thus, many mechanical and electromechanical devices have been developed that will introduce a nonlinear function between their input and output.

Although the mechanical devices such as cams and linkages have their fields of application, where practicable it is usually most convenient to build nonlinearity into the winding of a potentiometer. Depending on the degree of nonlinearity, the accuracy of the better nonlinear limits is normally only 1/5 to 1/20 the accuracy of the better precision linear potentiometers. Resolution and life also suffer in nonlinear units.

The following techniques and applications of nonlinear function generation are only representative. Care should be taken in choosing the most suitable technique for a given problem and in optimizing parameters. Often a combination of the various methods can be used where a high degree of nonlinearity is required.

Induction type electromechanical components are not covered since they are included in a later section.

MECHANICAL FUNCTION GENERATORS

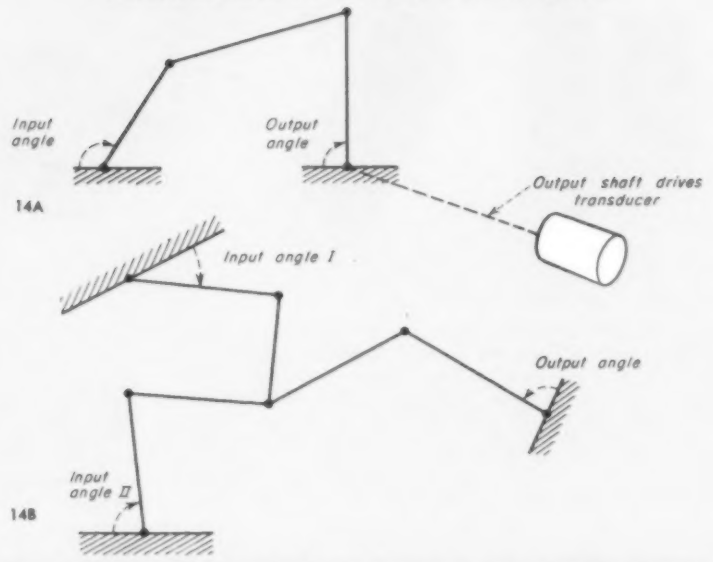


Fig. 14—Linkages are often used to develop functions of one or more input variables. Although compact and reliable, they are difficult to design and manufacture accurately. In (A), a linkage converter with one input variable is shown, while (B) illustrates an arrangement in which the output is a function of two input variables.

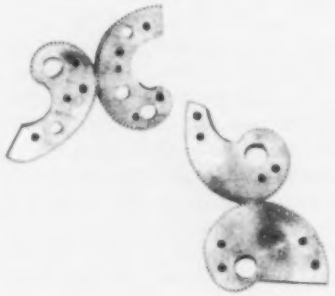


Fig. 15—Noncircular gears, while more expensive than linkages, are easier to design and can readily drive high torque loads. The gears shown here introduce a logarithmic variation of the output angle with the input angle.

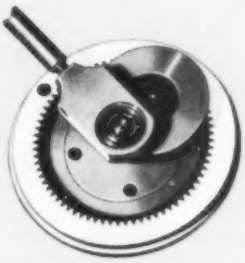
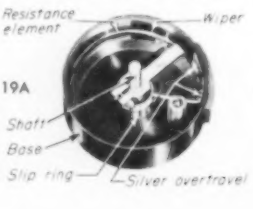
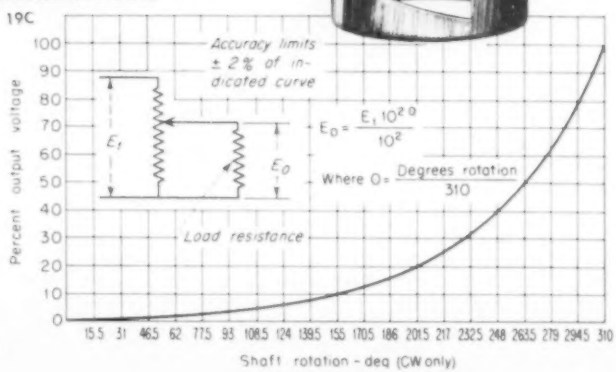


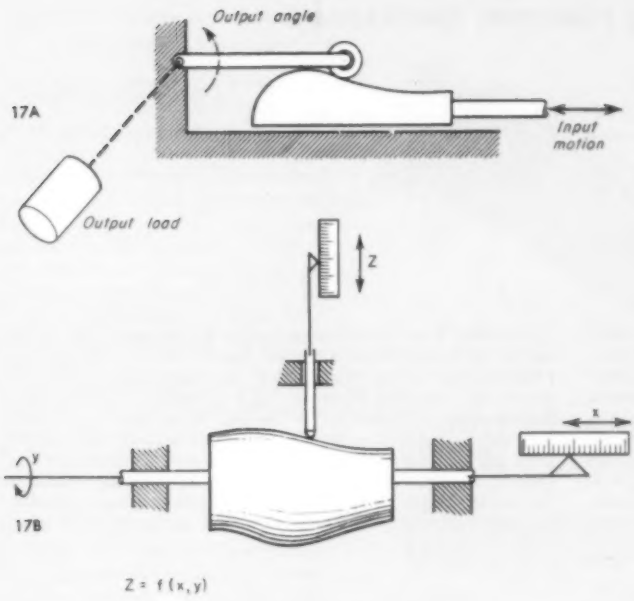
Fig. 16—In trigonometry problems, sine-cosine devices such as this Librascope mechanism are useful. The unit is self contained, weighs only 2 oz., and has an accuracy of 0.2 percent. Output displacements, varying with the sine or cosine of input angle, are available.

ELECTROMECHANICAL FUNCTION GENERATORS

Fig. 19 (A)—Typical tapered card potentiometer manufactured by the Technology Instrument Corporation. The shape of the card on which the resistance wire is wound determines the functional relationship between the input mechanical motion and the output electrical signal. Many special nonlinear functions can be generated by this technique. (B)—Giannini logarithmic resistance element. Accuracies of between one and two percent are possible by using shunting resistors mounted on terminal board inside the unit. (C)—Performance curve for a Giannini logarithmic potentiometer. A 100,000 ohm load is required to secure manufacturer's accuracy.

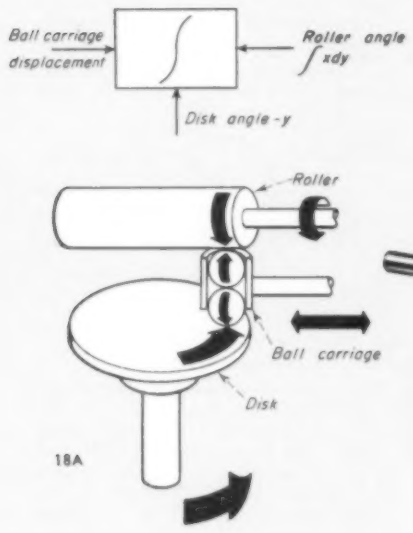






17C

Fig. 17 (A)—Many types of cams, such as the translatory cam shown here, can be used to develop nonlinear output functions. There is complete freedom in the use of either rotary motion or linear motion inputs and outputs. (B)—Three dimensional cams can be used to develop many functions of two independent variables. They are generally large, expensive, and develop high frictional loads. By driving X or Y uniformly, say by a synchronous motor, Z can be made a function of time. Cams such as these are used in automatic machine tools and in analog computers. (C)—Typical three dimensional cam manufactured by the Ford Instrument Company for use in an aircraft computing mechanism. It is machined to tolerances of 0.0005 inches on special pentograph tracing machine.



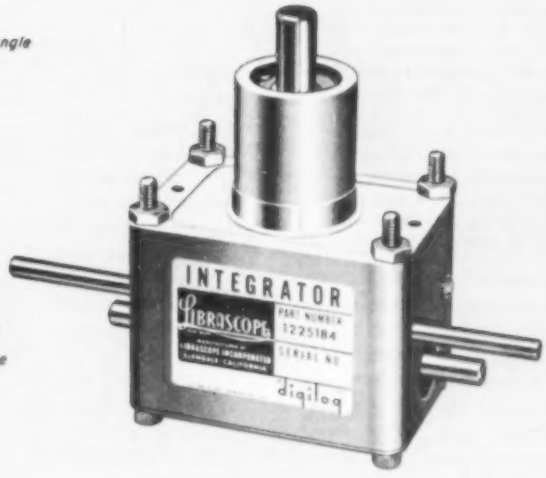


Fig. 18—The ball and disk integrator can be used for integration, as a variable speed mechanism or rate measuring instrument, and in suitable combinations—as an integrator of special functions or as a generator of solutions of differential equations. It can also be used as a continuous algebraic function computer. (A)—Schematics of integrator operation. The roller angle is the integral of the ball carriage displacement with respect to the disk angle. (B)—External view of standard Librascope integrator. Accuracy is 0.01 percent. Maximum input torque at zero load is 2 in.-oz, unit weighs 21 oz. and ball carriage shaft travel is 1½ in.

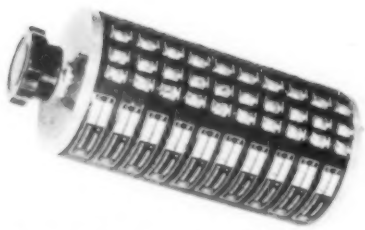
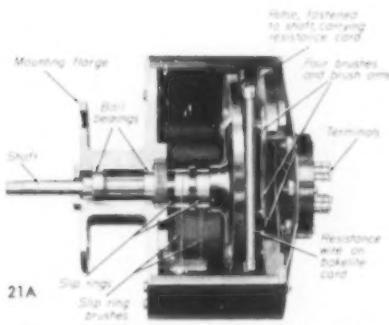


Fig. 20—Such problems as raising to powers or extracting roots can be solved by a series of successive multiplications on ganged nonlinear potentiometers. This ten ganged Type 748 Fairchild Camera and Instrument Corp. unit was designed to raise a function A to various powers up to A^{10}. Accuracy is better than 0.1 percent.



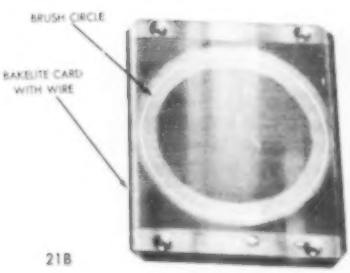
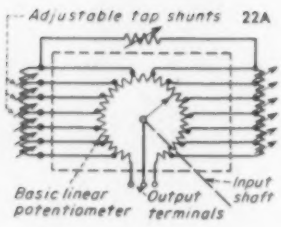
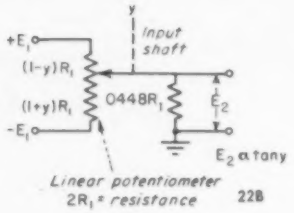


Fig. 21—Trigonometric functions can be accurately and smoothly developed by a special nonlinear potentiometer such as this Gamewell sinusoidal unit. The brush contacts move circularly over the uniformly wound rectangular card and pick off output voltages that are proportional to the sine and cosine of the input angle. Units of this type are accurate to about 0.5 deg and can be used in many control applications.





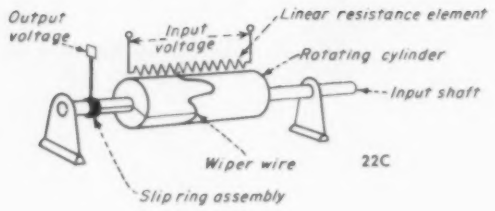
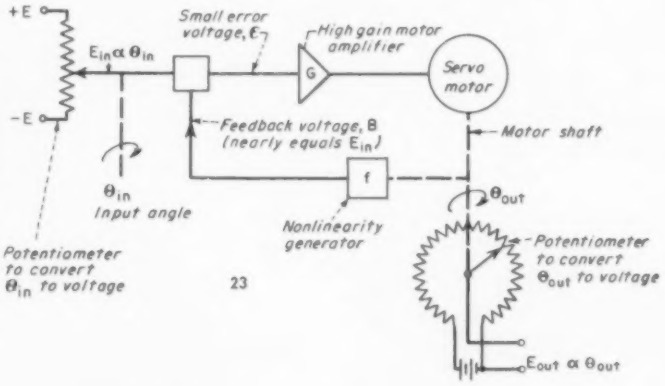


Fig. 22 (A)—Flexible nonlinear potentiometers can be obtained by taking 20 or more tap points on a precision linear potentiometer and shunting each tapped segment with a variable resistor. This type of universal function generator is useful for analog computer work and general purpose applications in the laboratory. The variable shunting resistors are adjusted to give the desired output as a function of input angle. (B)—Approximations to many nonlinear functions can be obtained by loading linear potentiometers and using various external fixed resistor networks. This is a simple and inexpensive arrangement where accuracies of less than 5 or 10 percent are required. This particular circuit can be used to generate a tangent function with an accuracy of plus or minus 0.1 deg up to y equals one radian. ***Electronic Instruments***, McGraw-Hill Book Co. (C) Cylindrical type function potentiometer designed by the Reeves Instrument Corporation. The wiper is secured to the drum in such a manner that it physically represents the curve of function to be generated. Thus, rotating the input shaft causes an output voltage proportional to this curve. The position of wiper wire can easily be changed to generate any reasonable function to meet customer specification.

Fig. 23—This servo circuit can be used to develop "inverse" linearities by means of feedback computation. If the nonlinear function generator, f, develops an output function B equals $f(E_{out})$, the servo motor will drive its shaft (E_{out} and Θ_{out} are proportional, and Θ_{out} is the input to the function generator) until B closely equals E_{in} (proportional to Θ_{in}). Then B equals $f(E_{out})$ equals E_{in}, and E_{out} equals $f^{-1}(E_{in})$, where f^{-1} signifies the inverse function. Thus, if f is a device for generating cubes, E_{in} equals $E_{out}{}^3$, and E_{out} equals $\sqrt[3]{E_{in}}$. If f is a device for generating logarithms, E_{in} equals $\log E_{out}$, and E_{out} equals $10^{E_{in}}$. This characteristic of inversion is useful in securing maximum flexibility in the generation of special nonlinear functions.



APPLICATIONS

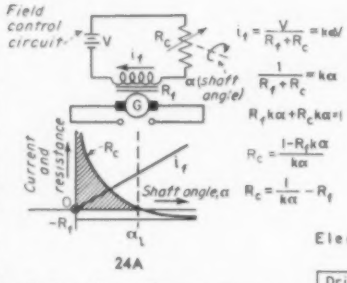
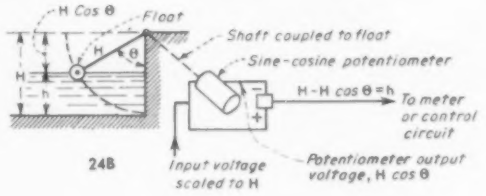


Fig. 24 (A)—Nonlinear potentiometer used to give a linear variation of generator field current with potentiometer shaft angle. By winding the potentiometer so that its resistance, R_c, versus shaft angle, α, follows the indicated curve, there will be a linear variation of i_f with α. Since R_c cannot be negative, it is physically impossible to achieve this relation above some shaft angle α_1. Because power dissipation decreases with decreasing current, wire size can be reduced as α is increased without danger of excessive overheating. This is a necessary condition to obtain this relation. (B) Application of nonlinear sine-cosine potentiometer to float type liquid level gage. Since the distance from the top of the fluid to the float pivot point is equal to $H \cos \Theta$, then H minus $H \cos \Theta$ is equal to the height of the fluid in the container, h. A mechanical cosine linkage can be used instead of the potentiometer if a mechanical displacement output is required. (C) Generation of sinusoidal wave forms by mechanical and electrical sine-cosine generators. In both devices, the input can be either d-c or an a-c carrier signal. Respective outputs are as shown by the curves for the two types of inputs. In the mechanical system the Wheatstone bridge is balanced for the mean position of the wiper of the linear potentiometer. This wiper arm oscillates sinusoidally to give a sine wave output at a frequency determined by speed.



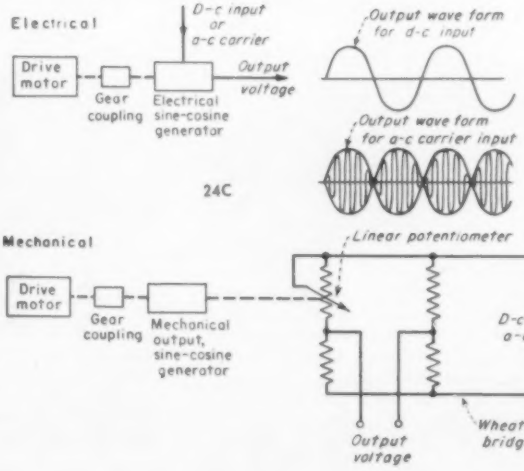


Table II—Comparison of Resistive and Induction Components

Reliability—Induction components are more reliable, particularly under extreme operating conditions.

Complexity—More auxiliary equipment is usually required in high accuracy induction component systems.

Cost—Approximately the same for both types of the same quality.

Resolution—Infinite for induction units. Resistive components are subject to resolution except in slide wire construction.

Radio noise—Negligible in induction components.

Isolation—Unlike resistive components, induction units have complete input-output isolation.

Scaling—In resistive units scaling can be readily adjusted by trimming resistors. However, the inductive device can include voltage stepup.

Voltage variation with frequency and temperature—Resistive components can operate at frequencies down to d-c, vary little with temperature change, and are insensitive to input voltage variations.

Impedance—Ratio of input to output impedance in inductive components facilitates the excitation and loading of these units.

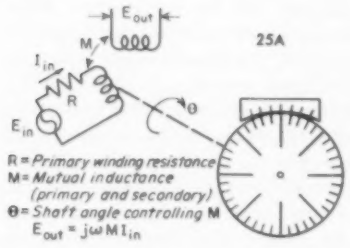
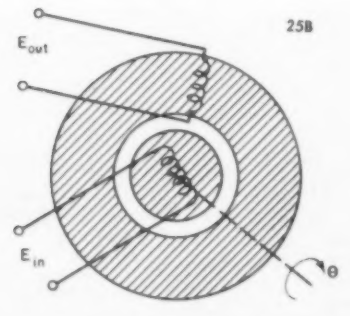


Fig. 25 (A)—Induction components are variable mutual inductances that follow prescribed curves of the variation of *M* with Θ. Frequently, more than two coils are used. In precise units, the output coil is lightly loaded and draws negligible current. The primary and secondary are installed on the rotor and stator of a motor-like assembly.



(B) These units differ from standard motors in the precision of the machining and quality of the core material.

Fig. 27—Exploded view of a 0.06 percent, 400 cycle Ford Instrument Corporation size 23 resolver. This unit, together with its dual channel compensating amplifier, makes up an accurate and very flexible trigonometric analog computer.

Induction Components

A LINE OF INDUCTION TYPE COMPONENTS, including sine-cosine generators or resolvers and induction potentiometers, is available to the control system designer. While these are analogous to the resistance potentiometers discussed in the previous sections, they have many advantages in function and performance over the resistive components, Table II. However, the induction units are more expensive, operate only on a-c and usually require more complex auxiliary equipment for maximum precision.

The induction type component is essentially a rotating transformer, Fig. 25, similar in appearance to a miniature wound rotor induction motor. One or more rotor (or stator) windings are excited by alternating current, and useful output voltages are induced in the windings on the stator (or rotor). These output voltages are functions of the input shaft angle, and are scaled to the input voltage.

Reliability

One of the advantages of this type component (in comparison with resistive devices) is an improved life expectancy. Standard induction components of many manufacturers are rated at 1,200 hours at 1,500 rpm for a total of over one hundred million cycles. This speed is above that recommended for precision resistive potentiometers.

The improved reliability is derived principally from the fact that induction components do not require a wiper arm, which moves along the potentiometer resistance element in resistive units. In the induction unit, the only sliding electrical contacts are on the rotor slip rings, where allowable friction is the principal limitation on brush pressure.

Induction components are free from contact bounce, wire hopping and have smooth stepless output leading to infinite resolution. Since output voltage is obtained from a magnetic field, it is not affected by length of service. No radio interference is generated by circuit interruptions.

Electrical Characteristics

The transformer nature of induction components permits the isolation of the input and output circuits. This is useful when voltages are to be added or subtracted, since special isolating transformers are not required and there is a free choice of ground points. Ground point selection is important because electronic amplifiers are often used with these components in control circuits. The possibility of voltage stepup within the component simplifies signal scaling in computer circuits. Also, the magnetic cores of the induction units serve as an electrostatic shield between the input and output windings. These windings are buried in partially closed slots on the stator and rotor. Winding capacitance to ground is of

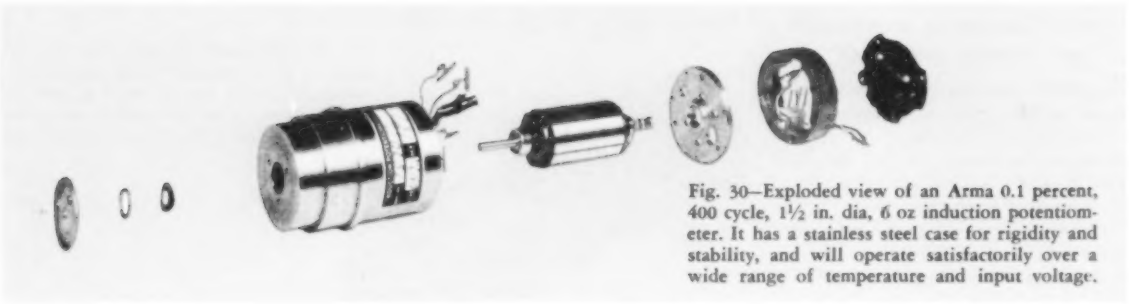


Fig. 30—Exploded view of an Arma 0.1 percent, 400 cycle, 1½ in. dia, 6 oz induction potentiometer. It has a stainless steel case for rigidity and stability, and will operate satisfactorily over a wide range of temperature and input voltage.

the order of a few hundred micromicrofarads.

The voltage variation with shaft position is a function of the primary winding distribution (which generates the air gap flux) and the secondary winding distribution. Skew (angular displacement of windings) is usually used to smooth the gradient changes resulting from the discontinuous nature of the coil arrangement in the slots. Skew also reduces the cogging effects from reluctance forces on the teeth.

Unlike the resistance potentiometer, there is no simple relation between the input and output impedances of an induction component. The input impedance of a lightly loaded unit is principally determined by air gap reactance (or main flux, as in any choke or inductive unit). Output impedance is determined by the resistances and leakages of the windings, and by the internal impedances of the voltage source feeding the primary. Generally, output impedance is a function of shaft position because of the varying coupled impedance between the primary and secondary coils.

Variable output impedance is undesirable, since it results in a changing output characteristic with load. This is in addition to the scaling change that occurs even when loading a constant output impedance. Where accuracies of a fraction of one percent are required, the load impedance may have to exceed the output impedance by a factor of 1,000 or more. To minimize the loading problem, manufacturers often prescribe standard loads that the user must specify to achieve maximum accuracy. These loads may correspond to the input impedance of some standard electronic amplifier often used with inductor units, or some other often used load. Dummy loading is sometimes required to meet manufacturers' specifications. In precise applications, cable capacitance must be included as part of the effective load.

Although computer and control circuits usually operate at some low audio frequency or on d-c, the high order of precision often requires the same attention to stray capacitances, grounding and pickup that is necessary at radio frequencies.

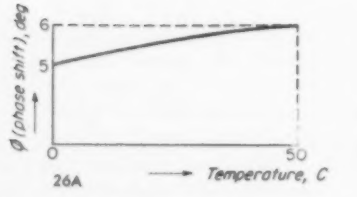
Many practical induction components have the input and output coils arranged so that output impedance is independent of shaft position. These units have the advantage of lower output impedance in relation to input impedance over similar resistive units. Other induction components have dummy windings that reduce the variation in output impedance by a factor of 2 or 3. However, these dummy windings must be located so that extraneous voltages are not introduced into the output.

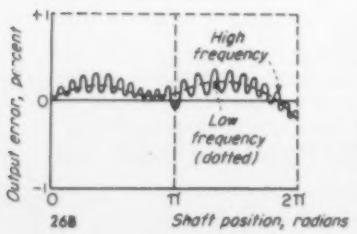
This uniformity of output impedance of induction components results in freedom from loading error and a frequent savings in electronic isolation amplifiers. Often components can be directly loaded on the output of an induction unit and scaling can be adjusted with a trimming network.

Phase Shift Compensation

In a-c systems, control and computation are performed by combining and operating on a-c voltages (or currents) which are usually in phase at some reference phase angle (usually zero degrees) or 180 deg out of phase. Thus, the amplitudes of the line frequency sine wave can be added and subtracted directly as can the voltages in a d-c system. Any phase shift (away from the reference phase) will result in an inaccuracy, since vector and algebraic sums will no longer be equal, Fig. 26. In addition, high performance closed loop systems are critically responsive to such phase shifts, and can cease functioning if the shift is excessive.

In resistive components, the phase shift problem is negligible since the principal error at low frequencies is caused by stray capacitances that can often be canceled out. In contrast, the phase shift in induction components is





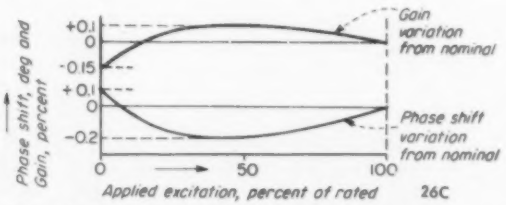


Fig. 26—Error characteristics of induction components. (A)—Variation of phase shift with temperature caused by changes in the primary copper resistance. (B)—Variation of output error with shaft position. The high frequency oscillation is caused by the slot openings and winding harmonics. The low frequency wave by poor machining. (C)—The mutual inductance of these components varies with input voltage. This introduces a variation in magnitude and phase of the output voltage that can be a source of error.

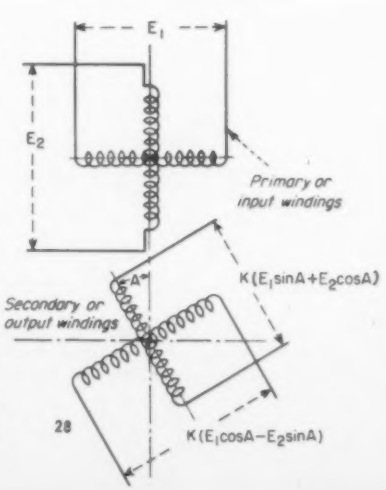


Fig. 28—Defining trigonometric relations for the electrical resolver. The constant *K*, used here, is a complex scale factor.

important. In miniature components, the resistance of the primary windings and the core loss combine to give normal phase shifts up to 10 or more degrees. This is inconvenient: all components operating together must be adjusted to the same phase shift. Small changes in temperature can also cause appreciable phase shift changes that must be matched for the various circuit components to obtain proper operation.

There are several methods of maintaining zero phase shift. The customer can purchase a set of induction components, and trim, scale and compensate by means of networks and temperature and frequency sensitive elements. This is the best approach where size is important although it is difficult to obtain accurate performance. Where standard sized components are used and bulk is not a factor, reliable nonelectronic systems of this type have been found practical. For good performance over wide shifts in temperature and frequency, tube and transistor input amplifiers are available that incorporate adjustments for scaling, phasing and compensation. These amplifiers also provide isolation.

One circuit uses special feedback windings, installed in the primary slots and coupled with the primary winding. The feedback winding measures the air gap flux and compares this flux with the primary excitation voltage through a feedback loop. By maintaining the flux and excitation voltage proportional at all temperatures and frequencies, the phase shift is brought to zero. This technique operates well at high frequencies and responds rapidly to transient environmental disturbances. One amplifier channel is required for each input winding.

Network compensation is an alternative approach to the problem. This means using a current feedback arrangement to effectively insert a temperature sensitive negative resistance in the primary windings, cancelling out the winding resistance. The winding leakage reactances can be similarly cancelled. The "resistanceless" component no longer causes phase shift and is unaffected by temperature variation. In addition, the absence of effective primary resistance results in a broadened frequency range without disturbing the scaling or adding to the phase shift.

With the above systems, the amplifiers are designed to give stable operation by means of heavy negative feedback. Variations in amplifier-component combinations are caused almost entirely by manufacturing variations in the inductive components. For this reason, all adjusting resistors are placed inside the cap of the rotating component: The amplifiers or rotating components can be replaced without the necessity of rescaling or rephasing the circuit.

Residual Voltage

Induction components develop residual voltages that have no analog in resistance component systems. In addition to the useful output voltage, harmonics are developed because of iron saturation. These harmonics increase sharply with increasing voltage and determine the maximum allowable voltage that can be imposed on the system. Because of this voltage limitation, little heat is developed in precision induction elements.

Quadrature voltages are also developed that are 90 deg out of time phase with the useful output. These quadrature voltages are caused by nonuniform conductivity in the electromagnetic circuit. It is impossible to cancel them out by rotating the shaft.

Because of these quadrature and harmonic components, there is a minimum residual or noise voltage at the null points (rather than a sharp zero). Since high-performance closed loop systems use high gain, easily saturated amplifiers, this residual voltage must be kept low by care in circuit wiring and by the use of high quality components.

Control of residual voltage is one of the most difficult manufacturing problems. Several techniques are available for quadrature and harmonic compensation, but these are either bulky and expensive or unreliable and introduce excessive time delays.

In addition to the generation of harmonics, iron nonlinearity causes other undesirable features. The variation of core permeability with flux density causes the internal coupling coefficients of the induction component to change with supply voltage. This introduces scaling errors and causes the null points to shift with supply voltage. The first effect can be reduced by the use of compensating amplifiers. Both effects can be minimized by the use of the new high permeability core materials such as Allegheny Ludlum's Mu-metal or Carpenter's Hymu. These core materials are expensive, and since they are strain sensitive, add to the handling difficulties.

The mechanical construction of induction units must be of a high quality: their accuracy depends on the distribution of flux in an air gap that may be 0.005 in. or smaller. Care in seating the mounting surface, accurate alignment, and freedom from shaft run out and eccentricity are required to obtain satisfactory performance.

These basic electrical and mechanical concepts apply to both induction resolvers and potentiometers.

Resolvers

Problems, such as the rotation of coordinates, solution of triangles for angles or sides, addition of angles,

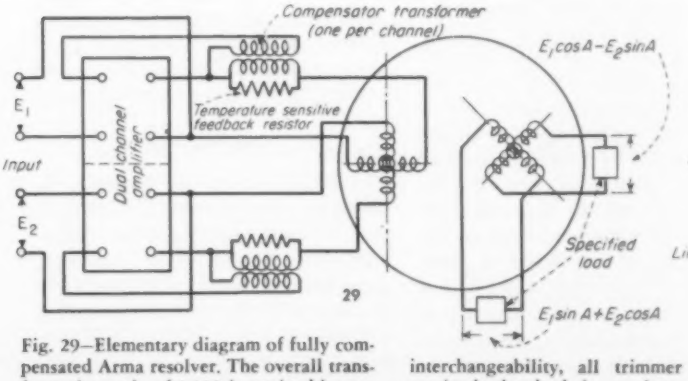


Fig. 29—Elementary diagram of fully compensated Arma resolver. The overall transformation ratio of 1.000 is attained by setting amplifier gain. Temperature-sensitive resistors bring the phase to zero over the entire temperature range. For maximum interchangeability, all trimmer resistors are in the head of the resolver.

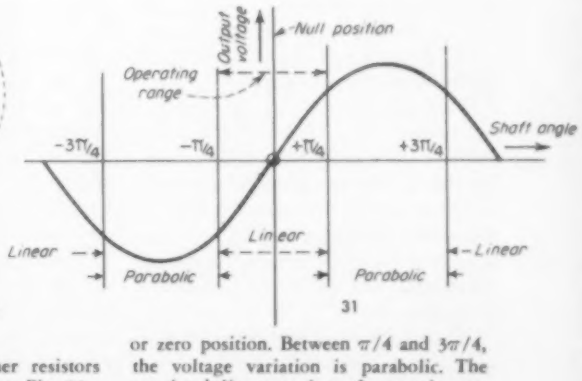


Fig. 31—The useful linear region for the Arma induction potentiometer shown in Fig. 30 is plus or minus 45 deg about the null or zero position. Between $\pi/4$ and $3\pi/4$, the voltage variation is parabolic. The restricted linear region of operation results in a fast acting control. However, the gear ratio must be high and backlash must be low, especially at the low speed end.

transformation between rectangular and polar coordinates, and the resolution, composition or addition of vectors, can be solved with electrical resolvers. The components can also be used for angle transmission where accuracies of less than 5 min of arc are required without the use of double sets of transmitters and receivers.

The induction resolver, Fig. 27, consists of a rotor and stator, each with two independent windings. The axes of these windings are 90 deg apart. The secondary or output voltages are sine and cosine functions of the angle of shaft rotation. In Fig. 28 is shown the defining equations for resolver performance and the winding details.

Compared to alternate devices for the solution of trigonometric problems, these induction units are unusually compact. For example, in the problems of vector composition and coordinate rotation, the induction resolver is equivalent to two separate card type sine-cosine generators, each with two outputs.

In accordance with the general discussion of induction components, the following precautions must be observed in resolver applications:

1.—All secondary windings must be terminated in the specified load whether they are actively used or not. Dummy loading may be called for.

2.—The primary windings must be excited from balanced low impedance voltage sources. If one primary is unused, it must be short circuited.

3.—All windings, used or otherwise, must be grounded in accordance with good practice in radio frequency circuits. Manufacturers usually specify these ground points.

The resolver shown schematically in Fig. 28 is the basic electromagnetic unit and requires compensation and standardization by means of trimming networks and booster amplifiers (these can either be designed by the user or directly purchased with the resolver as a complete combination). In Fig. 29 is shown a booster-resolver of the network compensated type, available as shown from the manufacturer.

Resolver accuracy can be specified in various ways. Since performance characteristics vary with changing supply voltage, frequency and temperature, in precise applications specifications indicate the extreme values of performance over the entire range of operating conditions. The following factors are important:

1.—Misalignment of axes from true quadrature.

2.—Variation in maximum transformation ratio from nominal (output voltage divided by input voltage with one primary excited at a time.)

3.—Variation in phase shift from nominal.

4.—Output voltage variation from a true sine wave as a function of input angle.

In the basic untrimmed component, scaling and phase shift may only be approximately specified, not as a measure of accuracy but as an aid to the user in designing compensation circuits. Axis accuracy and the sinusoidal variation of output with shaft angle are inherent in a particular component and cannot be improved by means of compensating circuitry. Also, since most trimming is performed on the primary windings, the transformation ratios with respect to both secondaries must be identical. No amount of primary adjustment can compensate for this type of inequality.

Often only one primary or one secondary is required in an application. Under this condition, axis alignment specifications and performance requirements of the unused winding can be waived. For this reason, manufacturers usually classify their production line output according to the number of available precision primary and secondary windings per component, thereby reducing production rejects.

The limiting factor in performance, whether the unit is compensated or not, is residual voltage, which determines the final sensitivity and accuracy of these components. Harmonic and quadrature voltages that appear at the null positions must be kept below the level of allowable accuracy. Those components of quadrature not resulting from a phase shift differential between the separate primary windings cannot be eliminated by adjustments of the primary standardization circuits.

Induction Potentiometers

Induction potentiometers, Fig. 30, are precision signal transformers having transformation ratios that can be varied continuously between fixed minus and plus values by mechanical rotation of the shaft. These transformation ratios closely approximate linear functions of angular displacement. Rotation can be continuous and in either direction. These units are available as alternatives to linear resistance potentiometers in applications requiring the special features of induction type components.

The linear variation of output voltage is obtained by the suitable distribution of primary and secondary windings. But since the linear function is nonperiodic, this linear variation of voltage with shaft position does not apply through the complete 360 deg of rotation. The angular performance limitations of a typical Arma induction potentiometer are shown in Fig. 31. This particular potentiometer has four coils; however, two of them are dummies, used to increase accuracy by improving the uniformity of the input impedance and output impedance with shaft position.

The restricted useable angle of the induction potentiometer has both advantages and disadvantages. Since the complete angular motion is obtained in less than one revolution, high ratio gearing is required between the potentiometer and its drive motor. Backlash must be low, particularly on the low speed end. On the other hand, an induction potentiometer can move rapidly between its limits of operation, resulting in a fast acting control. The small angular motion also reduces the tendency for wear at the slip rings.

Accuracy specifications of induction potentiometers are similar to those of a resolver having a single useful input and single output — with the following exceptions:

1.—The transformation ratio is specified at the maximum useable output, rather than at maximum coupling.

2.—Angular accuracy is based on the duplication of a linear rather than a sinusoidal characteristic.

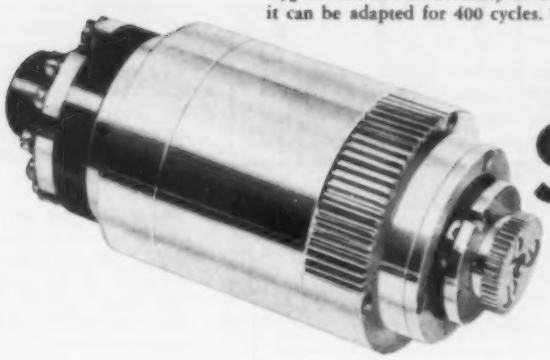
3.—There is no axis alignment specification.

Nonlinear induction potentiometers have been designed for such functions as the square of the angle of rotation or the tangent. However, these are not available as standard components. In general, the limitation on the number of iron core slots prevents the accurate generation of nonlinear functions. Where nonlinear functions are required, cams and linkages can be used to drive linear induction potentiometers.

Applications

The applications of the induction resolver and potentiometer are similar to those of the linear resistance potentiometer, mechanical type sine-cosine generator and the a-c excited card type potentiometer. For typical applications see those shown for linear potentiometers and nonlinear function generators.

Fig. 34—Magslip (synchro) manufactured by Muirhead and Co., Ltd., of England. Unit has 1½ in. dia and an accuracy of 0.25 deg. Though designed for 50 cycles (Admiralty Standard), it can be adapted for 400 cycles. The geared section of housing is for "zeroing" after mounting.



SYNCHROS

SYNCHROS ARE the basic remote transmission element in alternating current control systems, and are available commercially under a variety of trade names. While primarily angle transmission devices, the ease of converting physical data to angular form has extended their field of application and many unusual control techniques have been developed around them. For example, synchros can be multi-speeded to give accuracies of the order of a few hundredths of a percent, or they can be used to transmit data over distances of many miles.

These are induction type components and exhibit the good reliability characteristic of that class of devices. Synchros are inherently balanced, capable of continuous rotation and are relatively insensitive to line voltage and frequency fluctuations and temperature variations. Models are available for operation at 1,500 rpm and faster, high speeds for precision components.

Physically, synchros consist of a wound stator and rotor with either a single-phase winding or a three-legged Y connected winding. Single phase excitation, introduced into an arrangement of synchros, produces interacting magnetic fields that can be used for the remote transmission of torques or electrical signals. Fig. 32 shows a sectional view of a mechanically damped synchro manufactured by the Ketay Manufacturing Corporation.

As indicated by their basic functions, synchros can be divided into two groups: torque units and data transmission units. Torque synchros do not amplify torque; therefore, the energy delivered to a mechanical load at the output shaft of the receiving synchro must be supplied by the driving member at the input shaft of the transmitting synchro. This type of transmission is analogous to mechanically driving a load through a flexible shaft having considerable torsional resilience.

In contrast, signal transmission units develop an output error voltage proportional to the misalignment between the shaft of the receiving (or output) component and the shaft of the transmitting (or input) component. This error voltage is amplified and used to drive a motor that restores input-output correspondence by properly positioning the output unit shaft. Output torque can be as high as desired, depending on the capacity of the driving motor, since this torque is not reflected back to the input shaft.

Torque Synchros

A pair of interconnected torque synchros can be represented by the schematic diagram of Fig. 33. When the rotors are aligned and excited with equal voltages, the generated voltages in the polyphase secondaries exactly cancel and no stator current flows. When misalignment occurs, a resultant voltage is developed which causes current to flow through the leakage reactances of the two components. A stator flux is generated and a torque is exerted on the two rotors tending to align them. If the transmitter and receiver are identical units, the torque per degree misalignment is defined as the synchro torque gradient. In Table III are listed typical torque gradients and performance specifications for one manufacturer of synchros.

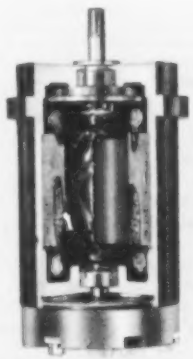


Fig. 32—Ketay torque receiver with characteristic salient pole rotor and mechanical damper. The damper consists of a bearing-mounted inertia wheel, coupled to the shaft by spring-loaded friction disk. Oscillations are damped by the dissipation of power in friction disk.

If the transmitter shaft is rigidly driven, the developed torque acts on the receiver rotor forcing it to follow the input. Long stator lines with appreciable resistance or a poorly regulated voltage supply, will cause a reduction in restoring torque and the following action will be inaccurate.

The effect of adding more receivers to a given generator or transmitter can be estimated by assuming that all units are identical and are equally loaded. Then the impedance of the system will be the generator impedance in series with the impedance of all the receivers in parallel. If there are n receivers, their total impedance will equal the impedance of one divided by n. Thus, the total impedance Z will be

$$Z = Z_T + \frac{Z_R}{n}$$

where

Z_T = transmittter impedance

Z_R = receiver impedance

Since generator torque, T_G, varies inversely with system impedance, the required torque becomes

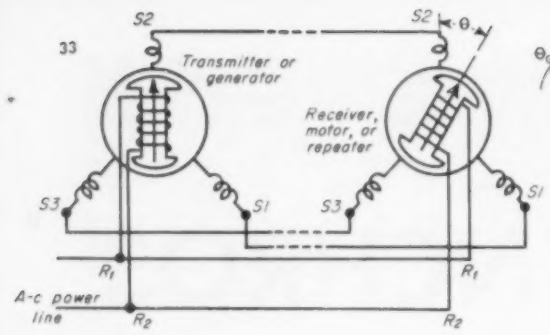


Fig. 33—A pair of torque synchros, out of synchronism by an angle θ. This misalignment causes current to flow in the lines, producing a resultant magnetic field in each synchro. Since these magnetic fields do not coincide with rotor flux axes, each unit will develop a restoring torque that tends to synchronize the rotors.

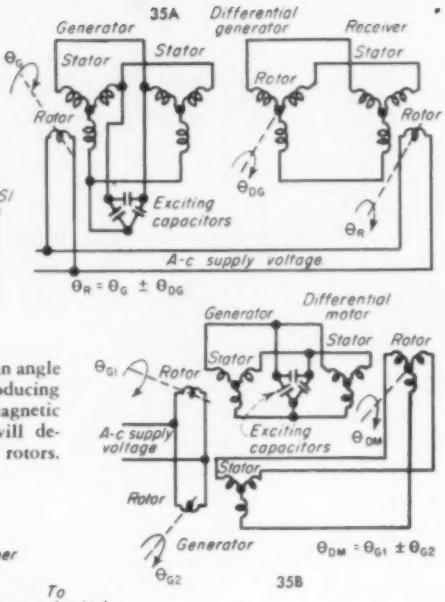


Fig. 35 (A) Differential generator circuit giving angular outputs at the receiver as indicated by the equation. These units are usually excited on their stator side, since the stator has maximum heat dissipation capacity. To prevent loss in transmission the primary legs are frequently tuned with capacitors.

(B)—Differential motor circuit in which differential gives the sum or difference of the generator input angles. As with the differential generator shown in (A), the motor stator is tuned with exciting capacitors to avoid overloading the generators.

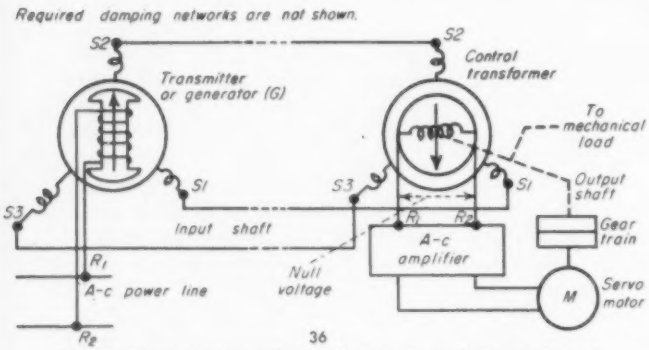


Fig. 36—Generator-control transformer transmission system. A change in generator shaft angle excites the system and causes stator currents to flow through the control transformer. A magnetic field is set up in the control unit, parallel to the generator field but 180 deg. out of phase. The output is driven to a null by the amplifier-motor feedback loop. The output load is only limited in size by the capacity of the amplifier and servo motor.

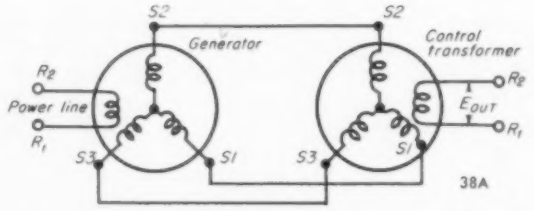
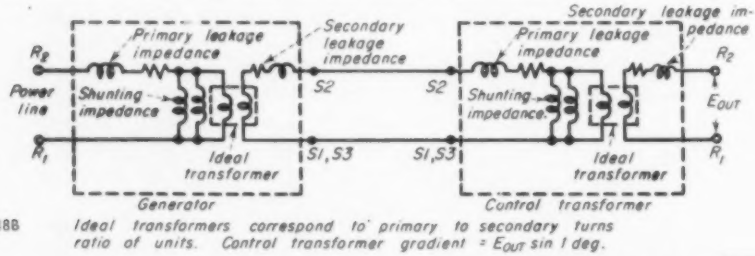


Fig. 38 (A)—Synchro system in the standard position for equivalent circuit analyis. Points $S1$ and $S3$ are at the same potential and can be connected. Maximum voltage appears across points R_1 and R_2, 90 deg away from the control transformer null.



(B)—Equivalent circuit of generator-control transformer system. The terminals are labeled for comparison with (A). The circuits correspond to a conventional two-winding transformer equivalent circuit with $S1$ and $S3$ joined in the position where they have zero potential difference.

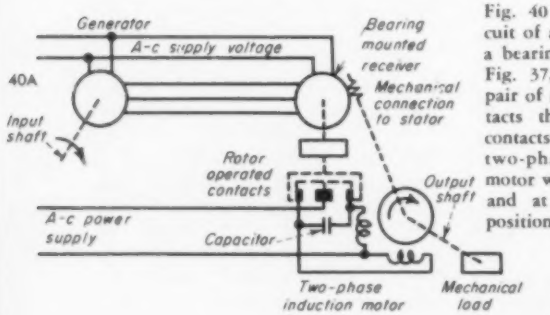
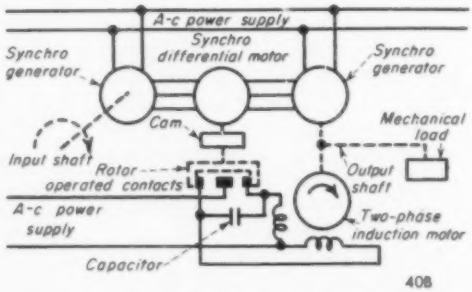


Fig. 40 (A)—Schematic circuit of a servo system where a bearing mounted receiver, Fig. 37, is used to drive a pair of motor excitation contacts through a cam. The contacts are connected to a two-phase servo induction motor which drives the load, and at the same time repositions the receiver stator.



(B)—This circuit is similar to that shown in (A) except that the bearing mounted unit is replaced by two units; a differential receiver and a generator. These circuits show the application of an on-off amplifier to a synchro system.

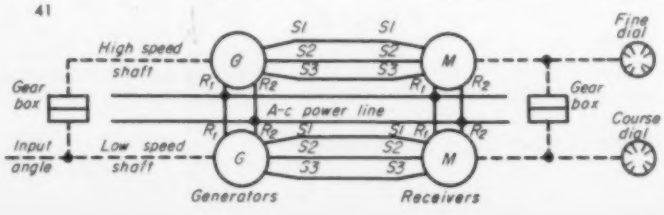


Fig. 41—Multi-speed synchro system used where accurate readings of the output shaft angle are required. Two pairs of torque synchros (generator and receiver) and two precision gear trains with identical ratios are required. The output shaft angle can be read to an accuracy of $\frac{1}{36}$ the synchro error, or about 1 or 2 minutes.

$$T_G = T_t \left(\frac{2Z_T}{Z_T + \frac{Z_R}{n}} \right)$$

where

T_t = synchro torque gradient

However, the available torque on each receiver, T_R, is

$$T_R = \frac{T_t}{n} \left(\frac{2Z_T}{Z_T + \frac{Z_R}{n}} \right)$$

To obtain maximum torque at each receiver, a large generator having negligible impedance, Z_T, compared to Z_R/n would be required. But this is uneconomical, and a generator having Z_T and Z_R/n approximately equal is usually selected. Synchro manufacturers specify the number of followers or receivers of various sizes that can be loaded on a generator without excessive loss of accuracy (Table IV).

The heating effect must be considered in the selection of a generator. The amount of power to be dissipated as heat should be determined with the synchro receivers at their maximum following lag angle since the heat generated will be greatest under this condition. Synchro manufacturers often specify the maximum unsynchronized lag angle that a unit can be held at without damage through heating. Care should be taken in selecting a mounting arrangement that will permit sufficient heat dissipation. Where the transmission lines must be fused, the transient power that is drawn during the synchronizing of randomly positioned receivers must be considered. This can be five to ten times rated power.

Because a receiver must follow a generator command without oscillating, a damping device, consisting of an inertia wheel and a dissipation element, is usually coupled to the receiver shaft, Fig. 32. The damping device causes smoother following and prevents the synchro from running as a single phase motor after a transient swing.

The accuracy of receiver following is restricted by receiver shaft friction, since the torque required to overcome this friction can only result from a lag or error angle. For this reason, low friction bearings and slip rings are used. The bearings may have spring separators between the balls to maintain uniformity and limit starting friction. Slip rings of minimum diameter and minimum brush pressure consistant with the electrical requirements are used. The uniformity of the magnetic circuit and accurate skewing reduce undesirable cogging effects.

Standard torque units are usually not accurate enough for computer applications, although it is possible to drive low friction potentiometers with an accuracy of a fraction of a degree. Torque synchros are useful in presenting display information such as driving dials and pointers. They have also been used as a first stage of amplification, driving a pair of electrical contacts connected to some type of high power drive; and for actuating a pilot valve in hydraulic control systems. In this latter application, the torque synchro is the electrical portion of an electrohydraulic servo amplifier.

To obtain the best performance, high inertias must not be coupled to the receiver since they tend to produce oscillations. Overhung loads that cause shaft deflections will increase friction, lag, and heating. Frictional loads are the most objectionable: they produce positional errors.

Another useful component, in the same class as the torque unit, is the differential synchro, available as both motor and generator. Differential units have three legged Y windings and can be identified by the three rotor slip rings. They are similar in behavior to mechanical differentials, but are especially suited to remote indication. Differential generators can be connected between a transmitter and receiver, Fig. 35 (A), and used to modify the electrical angle output of the transmitter. The receiver output corresponds to the sum or difference of the input angles applied to the transmitter and differential generator.

Differential motors, Fig. 35 (B), are used to indicate the sum or difference of the signals from two generators. Like torque receivers, they are designed for low friction and are equipped with damping devices to prevent hunting and single phasing.

TABLE III - PERFORMANCE SPECIFICATIONS FOR FORD INSTRUMENT CORP. TELESYNS.

SYNCHRO GENERATOR

Type	Weight	Torque gradient[1]	Accuracy limits[2]	Rotor inertia	Excitation	
	lb		Maximum minutes	oz.-in.^{2}	Amperes	Watts
1HG	1.22	0.085	18	0.34	0.13	3.3
1HG400	1.22	0.085	18	0.34	0.39	7.5
3HG	2.6	0.26	18	1.15	0.26	5.1
3HG400	2.6	0.26	18	1.15	0.91	6.2
5HG	5.0	0.47	18	2.96	0.38	5.4
5HG400	5.0	0.48	18	2 96	1.5	13.5
6HG	7.9	1.46	18	10.41	1.0	10.5
6HG400	7.9	1.41	18	10.41	2.5	20.0
7HG	16.2	3.60	18	31.7	2.2	15.0
7HG400	16.2	4.07	18	31.7	4.4	48.7

SYNCHRO RECEIVERS

Type	Weight	Torque gradient[3]	Accuracy limits[4]	Rotor inertia	Excitation	
	lb		Maximum minutes	oz.-in.^{2}	Amperes	Watts
1F	1.25	0.085	90	0.55	0.13	3.3
1F400	1.25	0.085	90	0.55	0.39	7.5
3F	2.8	0.260	36	3.28	0.26	5.1
5F	5.5	0.470	36	7.80	0.38	5.4
5F400	5.5	0.480	36	7.80	1.5	13.5

[1] In in.-oz/deg, using transmitter of equal size. Torque gradient measurements made using generator as a motor.
[2] Generator error is electrical.
[3] Measured in in.-oz/deg from synchronism.
[4] Receiver error includes drag friction mechanical lag.

TABLE IV - LOADING SPECIFICATIONS FOR FORD INSTRUMENT CORP. TELESYNS.

Generator Size	Maximum Number of Units Accurately Driven			
	1F Motors	3F Motors	5F Motors	Control Transformers
1	1	—	—	1
3	3	1	—	10
5	4	3	2	14
6	18	12	9	30
7	36	24	18	60

Note: Refer to Table III for specifications of listed units.

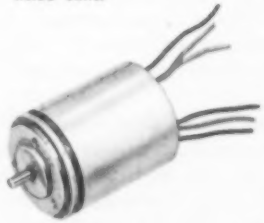


Fig. 39.—Pygmy Autosyn control transformer manufactured by the Eclipse-Pioneer Div. of Bendix Aviation Corp. Unit has a diameter of 15/16 in. and weighs 1¾ oz. It is accurate to 30 minutes of angle and was designed for use in miniaturized equipment or missile instrumentation.

Control Synchros

Control receivers or control transformers develop an output voltage proportional to the misalignment between the transmitter shaft and receiver shaft, Fig. 36. This signal is amplified and applied to a motor, and the receiver shaft is driven into synchronism. The motor drive can range in size from less than a watt to several thousand horsepower. No torque is directed back to the transmitter, and system dynamics are readily controlled. In spite of their complexity, such control systems have replaced many conventional torque transmission systems.

In control synchros, Fig. 37, the mechanical requirements of low bearing friction, built-in damping devices, and freedom from cogging torque are not as critical as in torque units. Also, these components operate at low power levels on amplified signals, and heating does not create a serious problem.

Control transformers are designed with a high input impedance so that they do not load the generator. In contrast, the generator has a low impedance, drawing a heavy line current. This combination results in good voltage regulation when the generator is loaded with a control synchro.

Normally, the generator allowable temperature rise is not exceeded when the generator is connected across the line with a rated control transformer load. However, if more control units must be driven, a larger generator is required since the generator load impedance decreases with the parallel addition of each control unit. Large size synchrol control transformers are rarely necessary since their impedance can be made sufficiently high in the smaller frame sizes.

Because a servo motor must be operated from the output of a synchro system, an adequate voltage gradient (volts per degree misalignment) of convenient phase angle must be available. Both of these factors can be determined by resorting to an equivalent circuit analysis in the preliminary design stages.

Consider a synchro system in the particular position shown in Fig. 38(A). The energized leads *S*1 and *S*3 are at the same potential in this position and can be connected together without affecting the system. This converts the transmitter and control transformer to two-winding transformers, having a single pair of input and output terminals. The voltage on the control transformer output is the maximum voltage, and when multiplied by the sine of 1 deg, yields the volts per degree gradient for the system. In general, the gradient will be complex and include a phase shift. By symmetry it can be shown that the gradient in a synchro system is independent of heading. Thus, the gradient determined for this specific position is the system gradient for all positions.

This reduces the problem to that of determining the control transformer output for the condition of Fig. 38(A). By replacing each synchro with its transformer type equivalent circuit, the system can be represented by Fig. 38(B). The equivalent circuit constants can be measured, or they can be estimated by applying transformer theory to the data supplied by the synchro manufacturer. In addition to transformation ratio, output gradient and phase shift, the following information can be obtained from an equivalent circuit:

1.—Variation in phase shift with temperature. (This can reduce servo motor efficiency.)

2.—The effect of frequency deviations; or of using various unspecified frequencies.

3.—Heating.

4.—Regulation.

5.—Output impedance of the control transformer in the system.

The proper use of an equivalent circuit can give the system designer a clear picture of system characteristics.

New Developments

The Bureau of Ordnance of the United States Navy has recently established a standard line of synchros. These units are of the highest over-all electrical and mechanical quality being mass produced today. Accuracies as low as six minutes of angle are specified for some types. The standardization includes not only performance specifications, but also dimensions and manufacturing methods. While the high specified quality has resulted in a proportional cost increase, the mass manufacturing feature should eventually counteract this.

Where accuracy is less important, the Bendix Pygmy synchros, Fig. 39, can be used. These small components (less than 1 in. dia) can be mounted directly in the case of indicating instruments. They are sufficiently accurate for the direct presentation of visual information. Servo motors of comparable size are also available to simplify the packaging of synchro systems.

TABLE V - PRECAUTIONS IN DESIGNING SYNCHRO SYSTEMS

1. The line resistance must be accurately matched to obtain precise following in synchro systems since control transformers develop quadrature voltages if resistances are unbalanced.

2. Capacitive and inductive reactance unbalance in the stator transmission lines introduces following errors in both control and torque synchro systems. Where several synchros are operated with a common stator lead to save wiring, particular care should be taken.

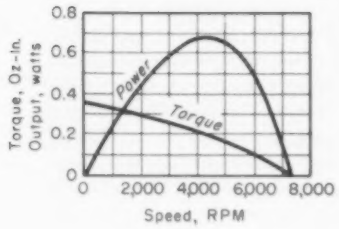
3. If a number of control transformers are driven from one synchro generator, and one of them is not following the transmitter, then any load resistance on the unsynchronized unit will reflect back into the system. This causes quadrature and angular inaccuracies at the synchronized components, and represents a limitation on permissible control transformer loading. Such excessive loading might be caused by a damping network across the synchro output terminals. Where all of the control transformers are continually following, loading introduces no steady state error since the units operate at the null point and draw no rotor current. When a low-input impedance magnetic amplifier is driven by a control transformer, amplifier input impedance can be matched with control transformer output impedance. This represents a heavy load.

4. If torque and control units are operated from the same generator, an oversize generator must be used. Otherwise, the receiver oscillations, and lack of smoothness in slow following caused by starting friction, will be transmitted to the control units. A large generator means low coupling impedance between control and torque units. In addition, torque units are usually operated at higher densities, resulting in harmonics being transmitted to the outputs.

Fig. 37—A Ford Instrument Corp. bearing mounted control transformer. These units often makes it possible to remove a differential motor or generator from a circuit, saving a component, see Fig. 40 (A) and (B). The slip ring construction shown here is compact and reliable.

Fig. 48—Exploded view of 5 watt, 400 cycle servo motor manufactured by the Ford Instrument Co. This unit has a solid iron rotor. It will start on a low control voltage and is relatively free from cogging. By inserting a 1 mfd capacitor in the circuit, single phase operation can be obtained.

SERVO MOTORS



CHARACTERISTICS			
Frequency		Cycles	400
Terminal Voltage Phase 1		Volts	* 26
Terminal Voltage Phase 2		Volts	26
Current, Phase 1		m a	* 170
Current, Phase 2		m a	* 170
Input	Total	Watts	* 6
Input	Total	Watts	** 7.5
Resistance @ 1		Ohms	66 ±4.6
Resistance @ 2		Ohms	66 ±4.6
Number of poles			6
Torque (Stalled)		Oz-in.	0.35
Temperature Rise		C	* 52
Temperature Rise		C	** 64
Speed		RPM	7,000
Reversing Time		Seconds	0.10
Moment of Inertia (of weight)		gm-cm²	2.44
Weight of Unit		Ounces	2.1

*Motor running at no load 7,000 RPM counter-clockwise.
**Motor stalled.

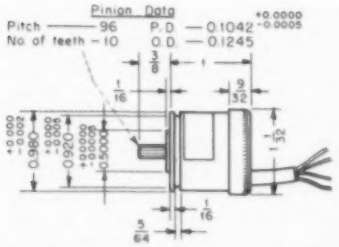


Fig. 42—Performance characteristics and curves, and dimensional data of a miniature a-c induction motor manufactured by the Kollsman Instrument Co. These units are used in instrument servos and packaged instrumentation.

Table VI—
Servo Motor Selection Factors

1. Linear performance characteristics.
2. Minimum control signal power requirements.
3. Adequate power to drive load.
4. Maximum figure of merit.
5. Rated speed must be sufficient to drive the load (through gearing) as fast as required by the input order.
6. Minimum time constant; ratio of motor plus load inertia to damping coefficient.
7. Suitable intermittent characteristics.
8. Good reliability.

IN MANY CONTROL SYSTEMS, a small amplifier-driven servo motor is used as the output power unit. For this type of application, motor performance must be specified not only as a capacity to drive a given load, but also in terms of the special characteristics required for closed loop system stability. Most of the present day theory covering closed loop systems is based on linear mathematical relationships: nonlinearities usually introduce unpredictable factors and impair performance, unless specifically incorporated in the design. Thus, a good general purpose servo motor must be approximately linear.

In motors, linearity means:

1. At any speed, torque is proportional to signal voltage.
2. Drag torque must vary linearly with speed (viscous drag).
3. Inertia must be constant.

For proper operation, motor performance should not depart appreciably from these conditions when a load is being driven. In Fig. 43 is shown a family of ideal servo motor performance curves.

Other factors that are important in motor selection are power rating, frequency response to a control signal, and maximum acceleration of a given load. When a constant control voltage is applied to a linear servo motor, maximum output power occurs at one-half maximum speed. If the load is dissipative (such as a friction load in contrast to the torque supplied to accelerate an inertia), the motor output gear ratio is selected to match the motor characteristics with those of the load.

Maximum motor speed must be sufficient to drive the output load at the speed required by the control system specifications.

An important figure of merit is the maximum acceleration that can be produced in a given inertial load. If load inertia is negligible in comparison with the equivalent reflected motor inertia at the load shaft, as is often the condition in instrument servomechanisms, then this figure of merit is equal to the ratio of rated motor stall torque, T_s, to motor inertia, J_M. If the load inertia is appreciable, and an output gear ratio is selected that matches motor inertia to load inertia for maximum acceleration, this figure of merit equals the ratio of rated stall torque to the square root of motor inertia plus load inertia, J_L. To obtain a maximum figure of merit, servo motors are designed for minimum inertia and maximum torque, resulting in a characteristic large length to diameter ratio.

The motor damping coefficient is a measure of the apparent viscous drag acting to reduce the developed torque as motor speed increases, Fig. 43. The ratio of rotor plus load inertia, J_T, to the damping coefficient, D, is called the motor time constant and has the dimensions of time. This ratio represents the time required for the motor to reach 63.6 percent of the final speed

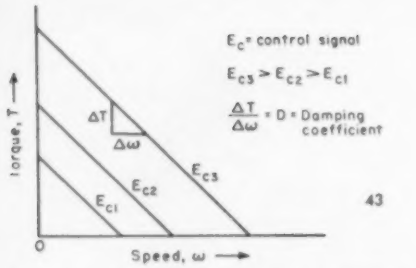
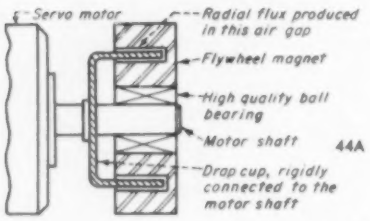


Fig. 43—Idealized speed-torque characteristics of a servo motor plus load. In most instrument servomechanisms, the output load is so heavily geared down from the motor that its contribution to the system dynamics is negligible.



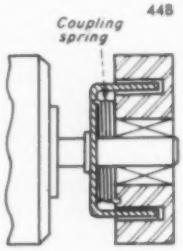


Fig. 44 (A)— Viscous coupled, flywheel oscillation damper. (B)—Similar damper to that shown in (A) with spring coupling. The spring adds an additional damping component which has its maximum effect at resonant frequency of the flywheel-spring combination.

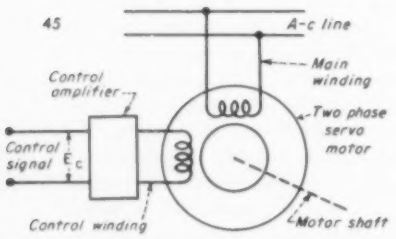


Fig. 45—Schematic of two phase servo control motor. The control amplifier can be of the electronic, magnetic or relay type. This motor, designed with high rotor resistance, gives the closest approximation to the ideal servo motor.

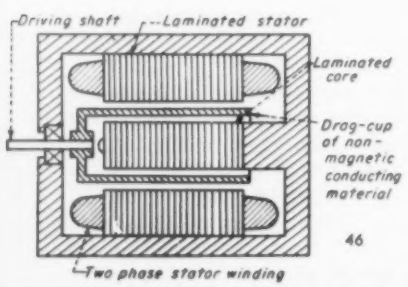


Fig. 46—Cross-sectional view of drag cup induction motor. This type of construction gives a high torque to inertia ratio and is free from cogging effects. One disadvantage is the large air gap (min. 0.030 in.) characteristic of drag cup motors. This limits motor size reduction.

after the sudden application of a control signal input, and is a measure of how well the motor responds to rapidly changing inputs. The reciprocal of the time constant divided by 2π, $D/J_T 2\pi$, represents the highest input frequency to which the motor will readily respond. This upper frequency is sometimes referred to as the servo motor bandwidth.

An additional measure of servo motor quality is the amount of signal power required to control the unit. This signal power is supplied by an amplifying device, so low signal requirements permit the use of small, inexpensive and reliable amplifiers. Often a large amount of bias power (which by itself produces no torque) is applied to a motor. This results in a high ratio of developed torque to control field signal power.

Servo control systems operate under a wide range of loading conditions; for example, the power requirements are high when initially synchronizing the system after a sudden change in input, while negligible power may be required during normal steady operation. Thus, the intermittent rating of servo motors is important, and optimum motor selection must be based on some estimate of the duty cycle of the system for space and economic reasons.

Like other control components, servo motors must have a high order of reliability so that they can be used in critical and inaccessible locations without excessive maintenance.

Servo Motor Damping

In an ideal servo motor, operating at a fixed control signal, torque decreases linearly with speed, just as if a viscous drag were applied to the motor shaft. This tends to damp out oscillations in closed loop systems by absorbing energy. The steeper the slope of the speed torque curve, $\Delta T/\Delta\omega$ of Fig. 43, the greater the apparent viscous friction, and the better the oscillation damping characteristics.

If the motor internal damping is inadequate for the stabilization of a closed loop, additional viscous friction can be added. A vane on the motor shaft rotating in a viscous fluid, or a conducting shell rotating in a magnetic field, can be used to increase viscous friction. It is possible for the driven load to supply viscous damping; in instrument servomechanisms, however, the load is usually geared down to the extent that its contribution to system dynamics is negligible.

While linear viscous friction (proportional to speed) is most desirable, cost factors sometimes dictate the use of nonlinear coulomb friction for damping (independent of speed). This can be supplied through the pressure contact of an oiled felt pad on a metal braking surface attached to the motor shaft. Many types of electrically controlled mechanical brakes are used in applications requiring rapid synchronizing and stopping. These brakes apply coulomb damping and can be of the continuously adjusted type, or can be applied discontinuously.

In a-c systems, damping can be obtained by feeding a portion of the control amplifier plate current through the motor control winding. This causes a viscous drag on the rotor. While this is an inexpensive and effective method, (saving an output transformer), the d-c bias of the iron permeability results in the generation of harmonics and a reduction in torque and efficiency.

All of the above damping methods add viscous or coulomb frictional drag to the internal damping characteristics of the motor. Although these methods are effective, they subtract from the maximum power available at the motor shaft since maximum power is limited by motor saturation or control amplifier saturation. In either case, it is reduced by the application of external drag. Where this reduction in motor power is objectionable, tachometer damping can be used.

The dynamics of tachometer damping are equivalent to those of viscous damping. A voltage, proportional to motor speed, is fed back to the input of the control amplifier so that under steady state conditions the speed voltage opposes the driving error voltage. Thus, by reducing the control amplifier input by an amount proportional to speed, the developed torque is also reduced by an amount proportional to speed. A similar result is obtained with viscous friction damping, but with tachometer damping it is still possible to use the full power capacity of the servo motor. This technique is widely used.

Both the frictional drag and tachometer methods of damping introduce an error proportional to speed. For example, consider a motor with externally applied viscous friction. While running at a fixed speed, a proportional drag torque is developed. This means that there must be an error signal input to the control amplifier of sufficient magnitude to develop this drag torque. Sim-

ilarly, with tachometer damping the voltage developed must be opposed by an error signal, so that the input to the control amplifier will approach zero (steady state null condition). Thus, there will be a following error between servo input and output of sufficient magnitude to balance tachometer output.

In positional servos, this velocity error is unimportant since the control system either moves slowly or stands still. However, where a continual, rapidly varying input is applied and accurate following is required, viscous or tachometer damping is not satisfactory. In this application one of the arrangements shown in Fig. 44 can be used. A heavy flywheel is coupled to the rotor shaft, either by viscous friction or by viscous friction plus a spring. At constant operating speed the flywheel rotates with the motor shaft and no drag is exerted. When the motor shaft oscillates, the flywheel inertia is unable to follow and the viscous dissipation caused by the relative motion will introduce damping.

Dampers of this type use either fluid or magnetic viscous coupling. Fluid coupling has the disadvantage of temperature sensitivity, although silicones are available that will operate satisfactorily over temperature ranges of about 50 C. Magnetic coupling is essentially insensitive to temperature changes although small variations can result from changes in drag cup conductivity.

TWO PHASE A-C SERVO MOTORS

The overall performance requirements for servo motors are most satisfactorily met by the two phase motor connected as shown in Fig. 45. The main field power is adjusted to give maximum torque per control field watt in keeping with temperature rise limits. The two field windings are usually identical and equally rated; however, where control power is at a premium, and the power required by the load is negligible, the main field may be rated at two to three times the control field.

These motors are inherently high speed, low torque devices, heavily geared down to drive the load. Because of their high speed, the kinetic inertial energy of the rotor is high and tends to prevent rapid changes in position or speed as required by the control system input order. Within limits, the torque to speed ratio can be improved in induction machines by increasing the number of poles. The fundamental torque-speed relation for balanced two phase operation is expressed by the following formula.

$$T = \frac{1352}{N_S} P_{RF}$$

where T = developed torque, oz-in.

P_{RF} = power transmitted to rotor, watts

N_S = synchronous speed, rpm

$$N_S = \frac{120f}{p}$$

f = line frequency, cps

p = number of motor poles

At stall, $P_{RF} = \eta\ P_{IN}$

where η = efficiency of transfer of input power to rotor

P_{IN} = total input power to motor.

and therefore, $T_S = \frac{\eta\ 1352}{N_S} P_{IN}$

where T_S = stall-torque, oz-in.

Since N_S varies inversely with p for constant input power, T_S can be increased by increasing p. However, as p increases, the coil span and flux enclosed per coil in the magnetic circuit of the machine, and therefore the inductance and exciting current decrease. This causes η to decrease. In practice, maximum torque is obtained by using the number of poles that gives the highest value of the product $\eta\ p$. The efficiency of power transfer to the rotor, η, also varies with air gap. For a constant number of poles, η increases as the size of the air gap decreases. Thus, lines of 400 cycle motors have been developed with 8-poles and an air gap of 0.0015 inches.

Choice of frequency can also be made by examination of the basic torque formula. Since synchronous speed increases with frequency, the stall torque of a 60 cycle motor is higher than that of a 400 cycle motor. This difference is not as great as indicated by the formula, however, since η decreases with frequency because of increased exciting current. This is particularly noticeable in small frame sizes where 60 cycle motor performance is poor. Although increased carrier frequency can improve control system operation in many ways, the stall performance of the servo motor usually suffers.

To obtain either special electrical or special mechanical characteristics for different applications, two phase control motors are available in many types and arrangements.

Variety of Mechanical Designs

Squirrel cage. The principal differ-

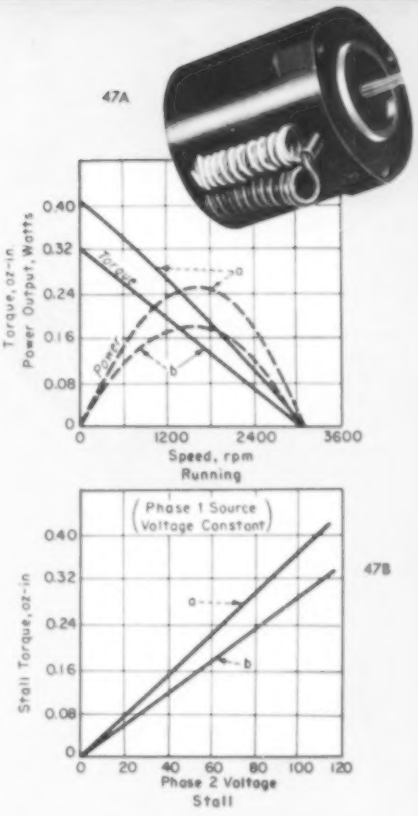


Fig. 47 (A) Kollsman, 60 cycle drag cup motor. The splined shaft can be used as the pinion in the first stage of gear reduction. This arrangement gives minimum inertia. In (B) are shown the running and stall torque performance curves of two motor designs that are available in the standard housing shown in (A).

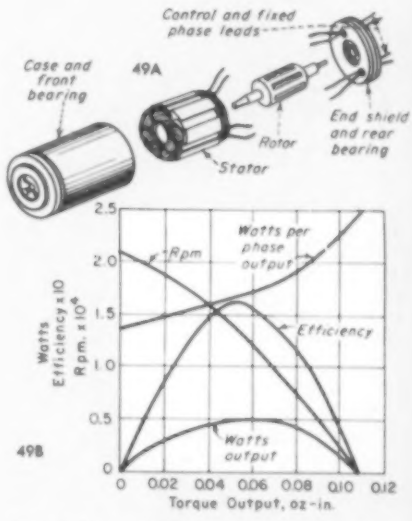


Fig. 49 (A) – Miniature servo motor (⅝ in. OD) showing closed stator slot construction. This unit is manufactured by the General Electric Co. The winding slots in the stator outside diameter are shunted by a stack of laminated iron rings, not shown. (B) – Performance curves for unit shown in (A). These compare favorably with the performance characteristics of similar open slot units. This construction reduces winding costs in small motors even though stator is complex.

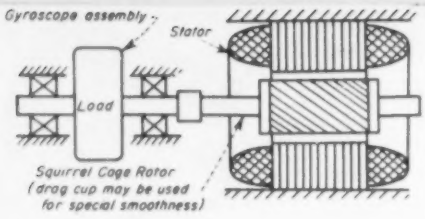


Fig. 50—Rotor and stator purchased as separate components. The rotor is coupled directly to the load and requires no additional bearings. The stator is mounted in a frame that is accurately aligned with respect to the rotor.

Fig. 51—Packaged servo synchronizing drive manufactured by Kearfott. This assembly combines two synchro control transformers and a motor-generator unit driving through gear train. Notice the plug in feature for easy maintenance.

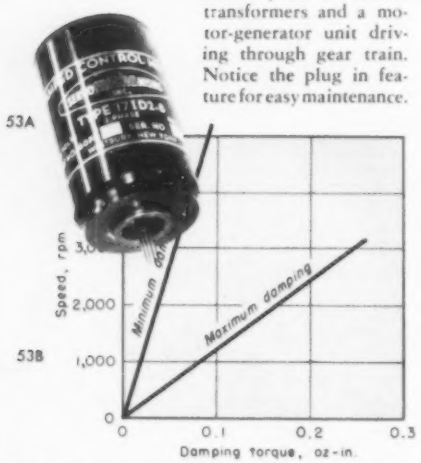


Fig. 53 (A)—Damped control motor, Type 171D2-8, manufactured by Servomechanisms, Inc. The damper is of the drag cup type. An adjusting screw regulates the axial position of a permanent magnet. Damping can be adjusted between the limits as shown in (B).

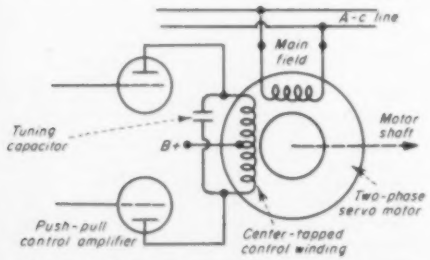


Fig. 54—Plate-to-plate operation of a two phase servo motor. This arrangement requires no output transformer, and no net d-c flows through the control winding to cause a reduction in efficiency. However, the insulation must withstand $B+$ to ground potential.

ence between a squirrel cage servo motor and a conventional squirrel cage unit is in the ratio of rotor to frame diameter. In the control motor this ratio must be small to give the low inertia and high rotor resistance required for servo operation. This type of motor will give the best over-all performance, and is especially efficient in converting input watts to shaft torque. In specific areas, it is inferior to other motor types as discussed below.

Drag cup. This component is similar to a basic squirrel cage motor with the squirrel cage windings removed from the rotor slots and formed into a drag cup of conducting material rotating in the air gap, Fig. 46. The slotted rotor laminations are replaced by a set of stationary iron ring laminations that provide a low reluctance path for the magnetic flux. This type of motor is noted for uniformity of developed torque with rotor angular position, freedom from cogging, and slot effects and low bearing friction resulting from the absence of radial air gap forces on the nonmagnetic rotor. In Fig. 47 is shown a Kollsman drag cup motor together with its performance curves.

In the past it was impractical to wind stators with the small inside diameter required for a low torque to inertia ratio, and the drag cup compared favorably with the squirrel cage in this characteristic. This was particularly true when aluminum was used as the cup material. But the lower-conductivity (compared to copper) aluminum required a greater cup thickness, and a larger air gap and higher stator copper losses resulted. The smallest practical air gap in drag cup units is about 0.030 in. With the present trend toward overall motor size reduction, this fixed limit has resulted in a low torque-per-watt efficiency in the smaller sizes of drag cup units. Today, this component is applied primarily where uniform torque and minimum bearing friction are a necessity. One application might be as a torque motor in gyroscopic equipment.

Solid iron rotor. As a compromise between the high performance of the squirrel cage motor and the uniformity of the drag cup unit, small servo motors are frequently built with rotors of pure unlaminated iron, Fig. 48. Since there are no rotor slots, there is no motor cogging (which is usually reduced in the squirrel cage by exact skewing). Some rotor nonuniformity exists because of grain effects in the iron, but careful annealing can make this negligible. In small servo motors, with few

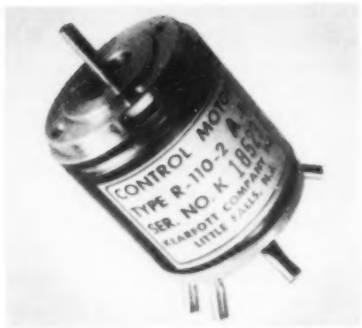


Fig. 52—High performance Kearfott servo motor, Type R110-2A. Stall torque is 1.45 oz-in. with 6 watts of control power. This unit incorporates several new features including a 0.0015 in. air gap and corrosion resistant nickel steel core material.

stator slots and a large number of poles, the limited distribution of the stator windings can result in the generation of space harmonics. These produce rotor losses in a solid rotor while a distributed squirrel cage winding would not respond to these harmonics. In addition, the pattern of rotor current distribution results in somewhat less developed torque.

Thus, the overall torque-per-watt input may be 20 percent less for the solid rotor than for the squirrel cage. Frequently this is unimportant in comparison with the gain in smoothness of performance, low control starting voltage, and reduced manufacturing costs.

Closed stator slots. To secure a maximum ratio of torque to inertia, the motor rotor diameter must be small. This makes it difficult to install the stator coils. Some manufacturers use special stator laminations, Fig. 49, which can be wound by machine from the outside, reducing winding costs and coil size. Since winding (either by hand or machine) is one of the most expensive operations in servo motor manufacture, a gain is realized, even though the two piece stator construction is more complex than the open slot type.

The closed slot unit has more inductance at low flux densities than the conventional stator, and sufficient control voltage to saturate the slot bridge must be applied before the motor will start. This reduces the accuracy of high quality servo systems. With high control field voltages, all slot bridges are saturated and performance is little different from that of the open slot. To compensate for the increased iron losses at the interface between the two stator sections, the closed slots reduce the irregularity in the air gap flux (and the resulting stray losses) by smoothing out

the abrupt density drop opposite a slot opening. They also reduce the effective length of the air gap, which in turn reduces the required exciting current and the stator copper losses. In general, the closed slot unit runs smoother and quieter.

Thus, motors of this type are distinguished by their low inertia and fast response, efficiency comparable to the open slot unit, uniform torque, free from rotor positional effects, and manufacturing economy. To secure the desirable performance features of the closed slot stator, rotors are sometimes constructed in a similar manner.

Articulated stator. Another method of lowering winding costs is to use an articulated stator. The complexity of the stator iron construction is offset by the lower cost of the machine-wound coils installed as the stator windings. Close fitting joints are required to secure a rigid symmetrical construction with a minimum of stray iron loss.

Separate rotor and stator sections. For maximum flexibility, some manufacturers will supply separate rotors and stators that can be designed into a user's equipment. Such an arrangement, used to supply precessing torque to the gimbeling of a gyroscope, is shown in Fig. 50. In this application, the friction load is low since no additional bearings are required. However, the stator mount must be rigid to avoid misalignment.

Inverted motor. In some special control assemblies, such as a gyroscope drive, an inverted motor construction is used. The wound stator is mounted on a fixed shaft, while the rotor assembly rotates about the outside diameter of the stator. While winding costs are low for this type of construction, it is normally only used where it simplifies the design of the end product. The gyroscope requirement of maximum inertia per pound makes the inversion a necessity in this application. The inverted motor is more efficient than a comparable conventional motor, particularly in the smaller sizes.

New Developments in Two Phase Servo Motors

Requirements for automatic control systems in military applications have resulted in several relatively recent developments in servo motors. Many of them can be used to advantage in industrial servo systems.

Subminiature motors. Motors having diameters of an inch and smaller, are finding wide applications in instrumentation. With these units, the mechanical hardware of entire servomechanisms can be installed in a meter. This compactness suggests the use of servos in place of mechanical elements (say for the remote transmission of a motion within a machine) allowing increasingly complex system designs.

Packaged servomechanisms. Units containing a motor, gear train, control transformer, resistance potentiometer and other components are available as packaged assemblies, Fig. 51. Designs are varied and flexible to meet the requirements of the user. In the military sphere, the Bureau of Ordnance has standardized on certain designs in a 1.5 in. frame, containing motor, gear train and two control transformers for use in a two speed transmission. Plug-in connectors are used wherever possible. These packaged elements simplify design and reduce instrument assembly and maintenance costs.

High efficiency servo motors. Improved machining techniques and precision bearings have led to the manufacture of servo motors with as many as 8 poles in frame sizes under 1 in. In servo work, more poles mean a lower gear ratio with reduced effective motor inertia and faster response. The number of poles that can be designed into a small motor is limited since the number of winding turns per pole and the total flux linkages and inductance decrease as the number of poles increase. This condition can be improved by reducing the air gap. Thus, motors are available with air gaps of about 0.001 in. High nickel alloys are used in place of the usual silicon steel as the magnetic core material to avoid the growth of corrosive material that could jam the gap.

Aside from the mechanical difficulties, further gap reduction is inadvisable because of increasing losses from tooth top and other leakage fluxes, and reluctance harmonics. Significant improvement in the efficiency of small 400 cycle motors, Fig. 52, is impossible without radical new developments in design techniques.

High temperature motors. Class H insulation, such as Teflon, and the silicone varnishes and bearing greases have resulted in the development of motors capable of operating at 160 C and higher. Maximum performance per pound can be obtained at these temperatures. These units are just becoming commercially available for servo applications.

Motor plus damper combination. Frequently, it is possible to stabilize a

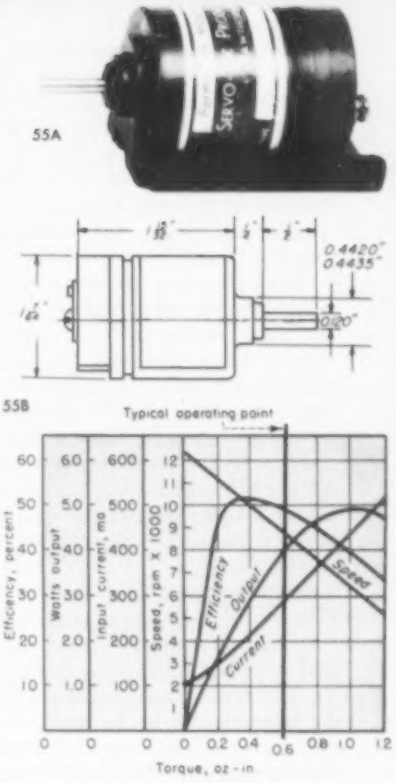


Fig. 55 (A)—A 27 volt d-c permanent magnet field motor (or generator) manufactured by the Servo-Tek Products Co. This unit is available with the baseplate, as shown, or without the plate for flange mountings. (B)—Outline and performance curves for the unit in (A). This motor has high torque and power ratings compared with a-c motors of equal size.

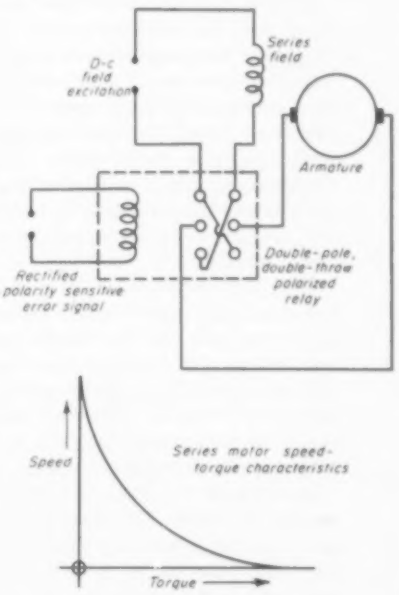


Fig. 56—Typical d-c Motor Control Circuits (A)—Relay operated control circuit for series motor. Some such arrangement must be used since the series motor is irreversible. The polarized relay is driven by a d-c error signal. The motor speed-torque characteristic curve shows the high stall torque and rapid reduction of torque with increasing speed. This results in good damping but gives a large velocity error.

feedback system by adding viscous drag to the motor shaft. Motor assemblies incorporating adjustable eddy current or mechanical damping are available, even in sizes under 1 in., Fig. 53. In the larger sizes (over 10 or 20 watts) this type of damping wastes excessive amounts of power and tachometer damping is used.

Motor-generators. Motors with a-c tachometers on the same shaft and in the same housing are available. The velocity voltage developed by the tachometer can be fed back in a closed loop system for servo stabilization. This arrangement gives flexibility of adjustment and good stabilizing characteristics. Similar units that include d-c motors and generators on one shaft and in one frame are also available for use in d-c servo loops.

Motors for plate-to-plate operation. Motors with center-tapped control field windings can be directly coupled to the plates of a push-pull output stage, Fig. 54. This arrangement produces no net d-c magnetization in the motor since the separate winding sections produce bucking magnetomotive forces. No output transformer is required. The disadvantage of this system is the high plate voltage imposed on the motor winding which results in a high dielectric stress to ground.

D-C SERVO MOTORS

Direct current machines of the series, shunt, or fixed excitation variety can be readily designed to give a wide range of performance characteristics. They develop high output power in a given frame size and require relatively small amounts of control power. Brush designs are available for high altitude operation, and hermetically sealed units will operate under extreme environmental conditions.

Their major application has been in aircraft control systems where the numerous controls and the weight and space limitations require motors that will deliver maximum power-per-unit volume. D-c servo motors are used where the duty cycle is intermittent or where high starting torques are required.

Even though d-c motors have certain advantages, there are compensating basic disadvantages in d-c control systems that have caused them to lose favor with system designers. Some of them are:

1.—D-c amplifiers drift (gradually develop an output with no input), and therefore require a drift trimming device or one of the relatively unreliable chopper-type drift cancelling circuits to give suitable operation.

2.—D-c motors have commutators that require periodic maintenance checks to insure reliable brush performance. This is usually not feasible where many miniature control motors are used in a complex mechanism.

3.—In small units, the commutators occupy a large percentage of available motor volume.

4.—D-c motors generate radio interference because of commutation, and filters are frequently required to suppress the noise.

5.—Isolation and matching of d-c circuits is difficult when compared with the use of transformers for these purposes in a-c circuits.

6.—The use of the induction type electrical resolver (for which there is no completely satisfactory d-c equivalent) by the military has led to the development of a-c systems.

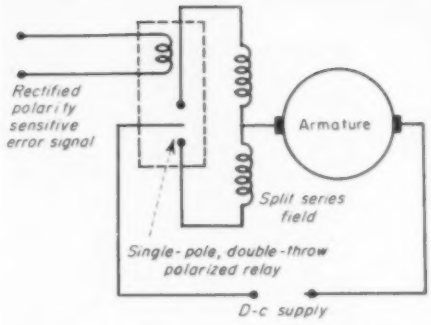
While d-c motors do not have the same internal damping characteristics as the two phase a-c motor, damping can be readily obtained by using anticipation or lead networks. Similar networks are sometimes used in a-c systems, but their performance is poor if the frequency varies by more than a few percent.

D-c motors can be wound for any reasonable armature and field voltage, and a variety of series and shunt field arrangements are available. Trimming resistors are sometimes included to allow the user to adjust the motor characteristics to suit.

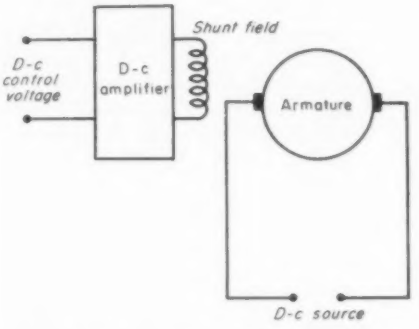
Where fixed shunt field excitation is required, permanent magnet fields can be used, Fig. 55. These give high field strengths, take up little space and improve efficiency since no field excitation power is required. In d-c machines that have fixed fields, careful armature skewing is necessary to prevent cogging and an increase in starting voltage.

Commutating poles are not used in small control motors since the high resistance of the commutated coil and shorted brush damps out inductive surges. During rapid reversals and transient conditions, brush sparking will occur.

The brushes of d-c control motors operate in the exact neutral to allow free reversibility. The brushes must fit properly in the brush holders to prevent an apparent brush shift caused by tilting of the brush. This condition can lead to closed loop instability in the vicinity of zero speed because of armature reaction feedback.



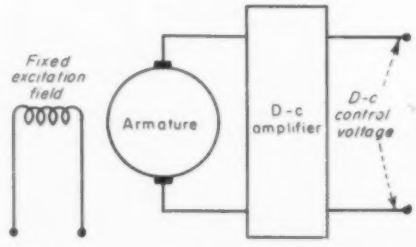
(B)—Series motor relay control circuit, simpler than that shown in (A). However, since two series fields are required, motor efficiency is not as high (one field is de-energized at all times). This arrangement is sometimes used with thyratrons in place of the relay.



(C)—Field controlled d-c motor. This is essentially a shunt machine excited on the armature. To prevent the time delay caused by the buildup of field current after the application of a control signal, the d-c amplifier should be designed to deliver current and not voltage. This can be accomplished by using current feedback, or a pentode output stage.

This arrangement is sensitive to iron hysteresis and residual voltage which can cause closed loop instability analogous to backlash, by introducing a lag between field flux and field current variation. This can cause difficulty at low signal levels where the components of armature reaction affect the control field. To obtain linear torque variation with control signal, armature current must be held approximately constant and not allowed to change with back emf. This is done by supplying the armature from a high resistance source.

The advantage of field control is that the power required for control (from d-c amplifier) can be less than 10 percent of motor power.



(D)—This armature control system requires a d-c amplifier that can supply full motor power, but gives more linear performance than the circuit shown in (C). It will operate satisfactorily in high gain systems. The required amplifier is designed to give output current (not voltage) proportional to input control voltage.

Speed Measuring Devices

TACHOMETERS develop an output signal proportional to shaft speed and can be used in control circuits either as the output element of a speed regulating system or to indicate the rate of change of a shaft position. Since instrumentation data are frequently encountered as a shaft position (or can be converted to such), the tachometer that measures shaft speed is a differentiator. Integration can be performed by using the differentiating tachometer in a feedback loop.

While there is practically an unlimited number of tachometer types, the induction generator, d-c tachometer, capacitive tachometer and drag torque tachometer are the principal ones versatile enough to be termed general control components.

The important factors in tachometer performance are the proportionality of output signal to shaft speed, and the freedom from unwanted residual voltages, such as harmonics and ripple.

Induction Tachometers

The a-c tachometer generator is used for integration, for system stabilization in closed loop circuits, and as the output element in velocity servos. Tachometer integration can be applied to improving closed loop accuracy (if the integral of the error voltage is brought to zero) or to actual process computation. A rather specialized application of this component is acceleration measurement. If d-c is introduced into the primary winding, the output voltage is proportional to acceleration rather than velocity.

The induction tachometer is similar to a two phase induction motor. However, the tachometer is excited on only one phase, and a voltage of line frequency approximately proportional to the speed of shaft rotation is generated on the unexcited or output phase. It can deliver a clean output of high accuracy, free of radio frequency noise and magnetic slot ripple.

The ideal unit has the following characteristics when a sinusoidal excitation is applied to the main or primary winding:

(1) Its output is proportional to shaft speed.

(2) At any speed, output voltage is proportional to input voltage.

(3) The phase of the output with respect to the input at any speed is either 0 deg or 180 deg, depending upon the direction of shaft rotation.

(4) The output does not contain any residual voltages.

A schematic representation of an induction tachometer is shown in Fig. 57. Generator excitation is applied to the primary stator winding. The secondary winding is located 90 deg from the primary winding and delivers the output voltage. The rotor is shown as a squirrel cage type, although drag cup rotors are usually used.

If the primary axis flux varies sinusoidally at a constant amplitude, a sinusoidal voltage of the same frequency, fixed phase, and proportional to rotational speed is generated in the secondary winding. This represents desired tachometer performance.

Stator leakage reactance and resistance, core losses, and bar inductance cause actual tachometer performance to vary from this ideal. These items introduce nonlinearity and a shift in the output phase with increasing induction generator speed.

Commercially available tachometers may be divided into two classes according to precision. Those having inaccuracies greater than about two percent are classed as low precision and find their greatest application as damping generators in servomechanisms. Those of higher accuracy, Fig. 59, are used in computer circuits and velocity regulation systems.

The best tachometers available today have accuracies on the order of one part in a thousand. Units of this precision are supplied with standardized output voltage-speed gradients and phase angles, and include temperature compensation.

Less accurate tachometers may be supplied as simple basic components, initially having broad tolerances and requiring adjustment and compensation by the user. These operations are performed through the addition of passive circuit elements, such as temperature sensitive resistors, to the input and output circuits.

Applications

In Fig. 58 (A) is shown a simplified schematic of a typical computer integrator circuit. In this application, the induction generator is driven by an induction motor. The motor is powered by the output of a high-gain amplifier which has as its input the error voltage existing between the output generator voltage, E_f, and the signal input voltage, E_s. The total angular rotation of the generator is transmitted through a gear reducer to the output potentiometer.

The induction generator is most widely used for velocity damping in conventional position servo systems, Fig. 58 (B). In this case a control transformer is remotely positioned in accordance with the angular input to a synchro generator. The induction generator and induction motor are mechanically connected to the control transformer output shaft, with the generator supplying damping proportional to shaft speed.

An error voltage, which is proportional to the difference between the input angle and the output angle, plus the output voltage of the induction generator, which is proportional to output shaft speed, are transmitted to the motor through a high-gain ampli-

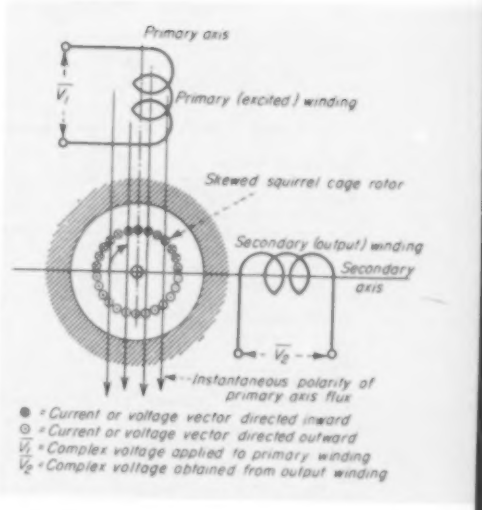
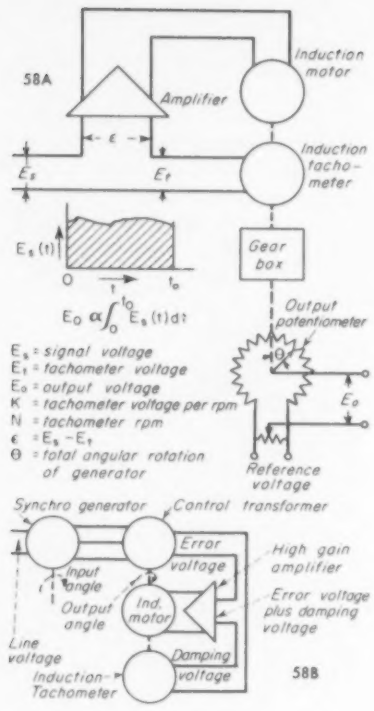

Primary axis
$\overline{V_1}$
Primary (excited) winding
Skewed squirrel cage rotor
Secondary (output) winding
Secondary axis
$\overline{V_2}$
Instantaneous polarity of primary axis flux
● = Current or voltage vector directed inward
⊙ = Current or voltage vector directed outward
$\overline{V_1}$ = Complex voltage applied to primary winding
$\overline{V_2}$ = Complex voltage obtained from output winding

Fig. 57—Schematic diagram of squirrel cage induction tachometer. If the primary flux varies sinusoidally at constant amplitude, a sinusoidal voltage of the same frequency, fixed phase, and proportional to rotational speed of the unit is generated in the secondary or output winding.



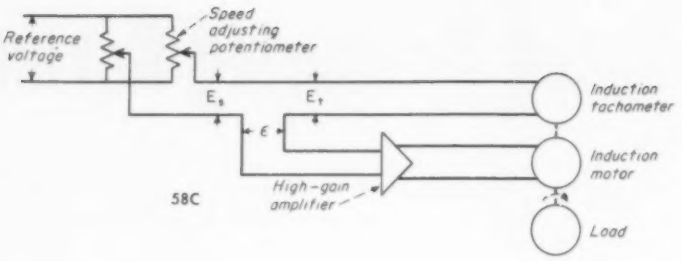


Fig. 58—Induction Generator Applications (A)—Simplified schematic of induction generator integrator circuit. With this arrangement, the output voltage, E_o, is proportional to the time integral of the input, E_s. The time integral of E_s is represented by the cross-sectioned area under the curve between time t equals 0 and t equals t_o. (B)—Conventional positional servo using an induction generator for velocity damping. An error voltage is generated proportional to a sudden change in input angle. This error voltage plus the tachometer output voltage are fed into a high gain amplifier to apply corrective torque to the control transformer. (C)—Induction tachometer speed regulating system. This is basically similar to the integrator circuit, (A). With ϵ small, E_t is almost equal to E_s so that E_s is proportional to motor speed. E_s and consequently motor speed can be set up by adjusting the potentiometer. Accuracy depends on reference voltage regulation.

fier. The addition of the damping voltage produces a corrective torque on the output shaft somewhat in advance of the time the torque would otherwise be applied.

A speed regulating system which is similar in basic details to the integrator circuit is shown in Fig. 58 (C). This system gives accurate speed control by the adjustment of a small potentiometer. The quality of the control depends on the regulation of the reference voltage and the accuracy of the tachometer.

Acceleration Measurement

The induction generator can be used to measure acceleration if d-c is applied to the main winding instead of a-c. Referring to Fig. 57, if the input is d-c, the quadrature flux along the secondary axis will also be d-c with a density proportional to speed. While the unit is operating at constant speed, the steady secondary d-c flux generates no output voltage. However, under rotor acceleration (changing velocity) the secondary flux varies and the secondary winding measures flux rate of change or acceleration. The output is not alternating (as is the output with an a-c input) but rather is a smooth voltage with an amplitude proportional to acceleration.

The principal applications are the direct reading of acceleration, and servomechanism stabilization and performance improvement. Just as tachometer damping in a servo is dynamically analogous to viscous drag, acceleration damping is analogous to inertia. By proper adjustment, "negative inertia" can be designed into a system for increasing the speed of response.

D-c Tachometers

While d-c tachometers have the widest general use, the tendency towards the use of a-c in complex closed loop systems (see section on d-c motors) is restricting their application in this field. However, under certain conditions, d-c speed measuring devices are used for integration, speed control, d-c servo damping and other applications similar to those of the a-c tachometer.

Direct current tachometers are inherently less accurate than their a-c equivalents. The best commercially available d-c units have linearity accuracies of about 1/4 percent, about five times that of induction generators. This results from the need for brushes, and from the commutation phenomenon in d-c machines.

To minimize these problems, the following factors are important in the design and application of d-c tachometer generators:

1. — Precise geometry and uniformity of brush material.

2. — Accurate location of brush and closest holder fit that will permit free sliding of the brush.

3. — Neutral symmetry to give identical performance for both directions of rotation.

4. — Light tachometer loading (10,000 ohms or higher) to prevent current pulsations in the commutated coil.

5. — Maximum number of commutator bars and winding coils to reduce ripple.

6. — High resistance brush material and risers (connection from armature coil to commutator) to reduce commutated currents.

7. — Equalizers (leads connecting winding points having theoretically equal potentials) to cancel out armature unbalance.

8. — Good dynamic balance to avoid vibration at the brush contact.

Temperature variations can affect field coil resistance and armature resistance, thereby changing the gradient and the commutated coil resistance. Gradient variation can be prevented by using temperature compensation, such as a thermistor circuit. Coil com-

Fig. 59—Combination units with induction generator and induction motor on one shaft by two manufacturers. Unit in (A) is by the Arma Corp. This single frame type is used in integrator circuits. Backlash is zero, improving the stability of closed loop systems. The Kollsman Instrument Corp. component in (B) has a diameter of 0.980 in. and a splined shaft for low inertia coupling to an output gear train.

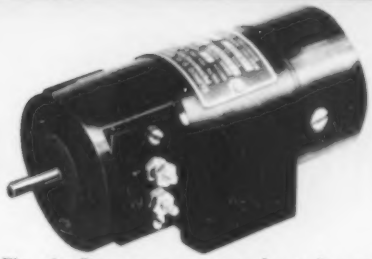


Fig. 60—Permanent magnet d-c tachometer by the Electric Indicator Co. This unit has a cylindrical permanent magnet whose axis coincides with the motor shaft axis. Rotating magnet adjusts tachometer gradient.

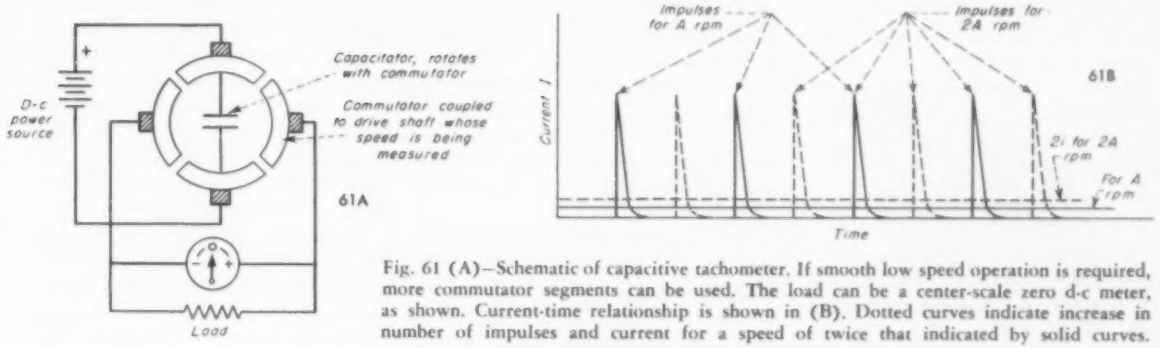


Fig. 61 (A)—Schematic of capacitive tachometer. If smooth low speed operation is required, more commutator segments can be used. The load can be a center-scale zero d-c meter, as shown. Current-time relationship is shown in (B). Dotted curves indicate increase in number of impulses and current for a speed of twice that indicated by solid curves.

mutation currents can be made negligible by following the suggestions listed above.

Permanent magnet tachometers, Fig. 60, are compact, efficient, reliable and have a high output gradient. Manufacturers use adjustable magnetic slugs to standardize the gradient. The Alnico magnets used in these devices are insensitive to temperature variations and to the demagnetizing effects of accidental output short circuits. However, unlike the externally excited generator, the output of the permanent magnet generator does not vary proportionally with line voltage.

In high quality systems, all elements are excited from a reference line that sets the standard component scale. When these components are interconnected and servo driven to null, line voltage fluctuations affect all of the system elements in the same manner and no errors occur. This arrangement avoids the need for a regulated power supply having regulated output magnitude of the same order as system accuracy. Since the permanent magnet tachometer is insensitive to line voltage fluctuations, it cannot be combined with other components unless a regulated power supply is available.

Miscellaneous Speed Measuring Devices

Of the many other devices for measuring speed, the capacitive tachometer and the drag torque tachometer are of particular interest.

The capacitive unit is an accurate reversible d-c tachometer, Fig. 61. As the commutator rotates the condenser alternately charges from the d-c power sources, and discharges through the load. The polarity depends on the direction of shaft rotation. This type tachometer is manufactured by the Metron Instrument Co.

This component has the following characteristics:

1. — Delivers an output scaled to line voltage, permitting its application in closed loop systems.

2. — Its output is linear with speed if the speed does not become so great that insufficient time is available for charge and discharge.

3. — Develops a spiked output wave that becomes troublesome at low speeds. This is the limiting factor in its application.

4. — It can be made independent of temperature variations.

Drag torque tachometers can be obtained in many physical forms, all of which incorporate the basic features shown in Fig. 62. The rotating input shaft plus magnet produce an eddy current torque on the drag cup causing it to deflect against its spring. By using a precision wound spring, this deflection can be made proportional to shaft speed.

With a low torque potentiometer or an induction pickup unit on the deflected shaft, an output signal of any convenient scaling and frequency can be developed. This freedom of choice is important in control applications.

This unit is difficult to temperature compensate because of variations in the drag cup, the spring and the permanent magnet. Low friction bearings are required for accurate operation.

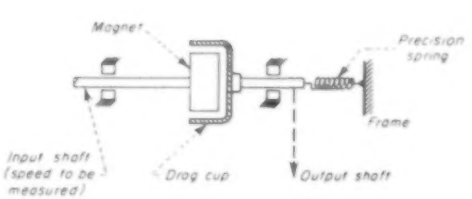


Fig. 62 — Schematic of drag torque tachometer. The shaft mounted magnet can either be of the permanent type or a d-c excited field. The output shaft can be connected to a low torque potentiometer or induction potentiometer for speed indication or control.

Miscellaneous Control Components

MANY SPECIALIZED COMPONENTS are available that have occasional application in control systems. A good number of these have been developed by individual companies and find their widest application in products manufactured by these companies. However, their use can often simplify the solution of specific control problems.

These components can be divided into three groups; special motors, variable transformers, and miscellaneous angle transmissions.

Special Motors

Hysteresis motors. These are synchronous machines based on the use of a strong rotating permanent magnet rotor. In small sizes they compare in efficiency with induction motors, but are more expensive because of low quantity production. Hysteresis motors develop relatively constant torque and draw constant current while accelerating from standstill. They are distinguished from conventional synchronous motors by their capacity to synchronize any inertia whose losses the motor can supply. This has resulted in their use as a gyroscope drive.

The hysteresis motor has a smooth unslotted rotor, Fig. 63, resulting in quiet operation and freedom from cogging. These features, together with its well damped synchronous performance (no hunting), have caused it to be used in audio equipment. In control applications, hysteresis motors are used as time bases and for synchronizing circuit switching. The synchronous speed can be controlled, Fig. 64, by varying the line frequency or changing the number of poles.

Torque motors. These components are designed to develop high torque with a small displacement. They are used for positioning hydraulic valves, maintaining constant tension and opening and closing electric circuits.

The unit shown in Fig. 65 can be operated directly from the plates of a servo amplifier, and develops up to 5 lbs. of thrust in the stalled-zero position.

Conventional servo induction motors, capable of continuous operation in a stalled condition, can also be used as torque motors; however, they do not compare in torque per watt with the d-c units designed specifically for this type of operation.

Step motors. These units are used for remote angular positioning in discrete steps. They consist of an array of d-c actuated stator coils and a d-c excited or permanent magnet rotor. The transmitter is a multi-position rotary switch or equivalent, which excites the various stator coils of the step motor. Remote positioning is obtained since the rotor axis will align itself with the axis of stator excitation.

Under intermittent conditions, motors of this type can develop high torques in small frame sizes. This makes them ideal for turning heavy rotary switches. Motor output can be increased by using high temperature electrical insulation.

Table VIII — Comparison of Variable Transformer and Resistance Potentiometer.

Regulation and Loading — Variable transformer is less susceptible to loading and can be used to feed components without booster isolation.

Calibration — An adjustable input tap gives flexibility in setting scaling of variable transformer.

Resolution — Transformer has infinite resolution and can be used in high gain servo loops.

Stray voltages — Transformer gives a clean output free from residual voltages. This component will not pick up stray inductive or capacitive voltages because of its low output impedance.

Compactness — The resistance potentiometer is more compact than the variable transformer for equal accuracies; however, the reduction in auxiliary electronic equipment may result in a more compact overall transformer system.

Accuracy — Since the variable transformer is not adaptable to multi-turn construction, accuracy is limited to 0.1 percent.

Life — Transformer life is several times that of resistance potentiometers.

Flexibility — Both components can be wound linearly and nonlinearly. One or more variable input and output transformer taps permit many circuit variations.

Frequency range — Transformer cannot be used on low frequencies or d-c; however, high frequency limit is 10 kilocycles or higher.

Integrating motors. Manufactured by Specialties, Inc., these units operate at an output speed proportional to the d-c input voltage. Linearity is about ½ percent and they are equipped with jewel bearings and low friction platinum iridium brushes. The principal application is in d-c integrating circuits, although they compete directly with the 0.1 percent all-electric integrator.

The Specialties motor can start and run on the energy supplied by a small photoelectric cell. Under a no load condition with a 0.1 volt input, the unit draws 25 microwatts.

Rotostepper. The Rotostepper, Fig. 66, manufactured by Giannini, is a source of intermittent rotary power. It consists of a solenoid operated stepping mechanism that gives controlled stepping, or incremental shaft rotation, in either direction. Stepping frequencies can be as high as 60 per second. The unit weighs 13 oz and delivers 10 oz-in. at 15 steps per second. Built in synchronized precision potentiometers are available. Minimum life of this component is 50,000 steps.

Variable Transformer Potentiometer

A variable auto-transformer, Fig. 67, can often be used in place of a resistance potentiometer with a resultant improvement in performance and flexibility, Table VIII. This component is widely used in foreign control systems, but in spite of its advantages has found little application in this country.

The magnetic circuit of a precision variable transformer consists of a toroid, built up of ring shaped laminations of high permeability nickel steel, Fig. 68. As many turns of fine wire as possible are wound on the iron stack in keeping with the mechanical strength and life requirements. A wiper arm, rotating about a centered axial shaft, contacts the various turns. If two winding tap points are electrically excited, the wiper will pick up an output potential which varies linearly with angular shaft position. In this respect, this device is similar to a conventional linear resistance potentiometer.

A self-aligning carbon roller is used as the wiper. It is this feature that

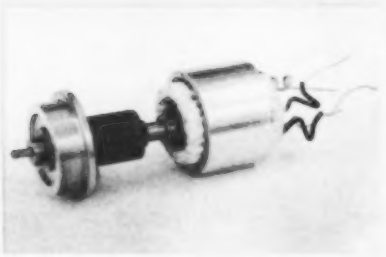


Fig. 63—Internal construction of Muirhead hysteresis motor. The rotor consists of ring stampings of permanent magnet steel. Input power is 20 watts at 50 cycles, with an efficiency of 20-30 percent. The efficiency of hysteresis motors increases with frequency.

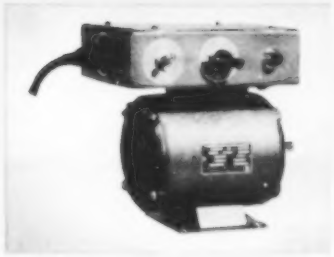


Fig. 64—Elinco Type GH-371 multi-speed hysteresis motor. Synchronous speeds of 900, 1,800 and 3,600 rpm are obtained by switching pole connections. Units are available 3-phase, 2-phase or single phase with a capacitor.

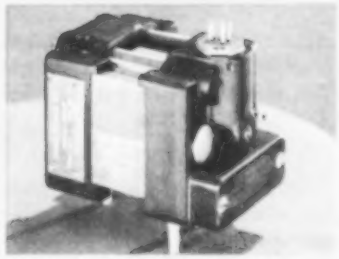


Fig. 65—Electrically operated valve actuator or torque motor manufactured by Trans-Sonics, Inc. This unit is of the spring restrained type and used mainly for pilot valve positioning in high quality hydraulic servo systems.

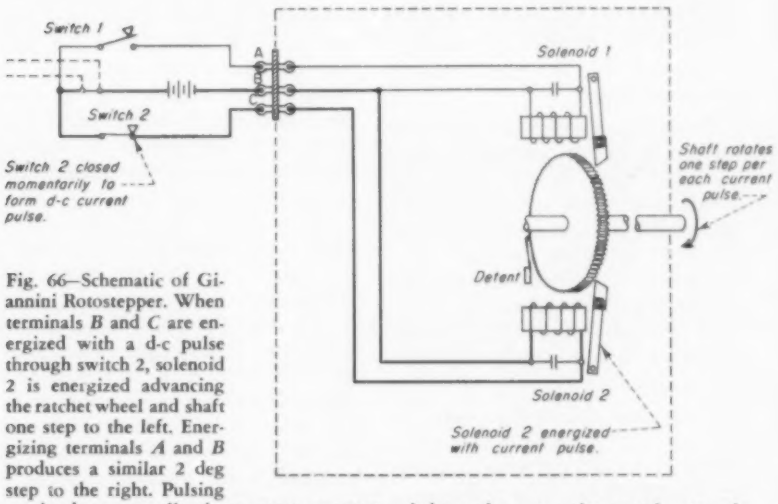


Fig. 66—Schematic of Giannini Rotostepper. When terminals *B* and *C* are energized with a d-c pulse through switch 2, solenoid 2 is energized advancing the ratchet wheel and shaft one step to the left. Energizing terminals *A* and *B* produces a similar 2 deg step to the right. Pulsing can be done manually via momentary contact switches or by automatic or semi-automatic chopper or pulser. Unit is used to transmit shaft angle information in discrete steps.

Fig. 67—Variable transformer, Ipot, manufactured by Muirhead. Unit operates on 50 cycles with an accuracy of 0.1 percent. It can be readily adapted for use at 60 cycles, 400 cycles or other audio frequencies, and can be used to divide or obtain reciprocals without the use of complicated servo systems.

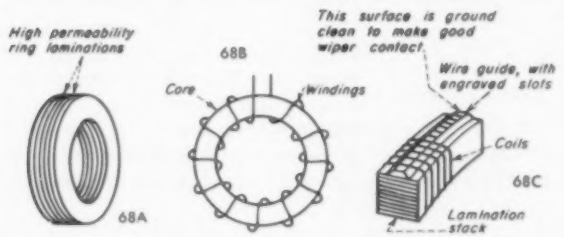


Fig. 68(A)—Laminated stack of toroidal punchings constitute the magnetic circuit of the inductive potentiometer. The turns of fine wire are closely and uniformly wound on the toroidal core, (B). The section of the partially wound stack, (C), shows how the windings are placed in engraved grooves in the wire guide. The carbon roller makes good contact as it rides along the bare track.

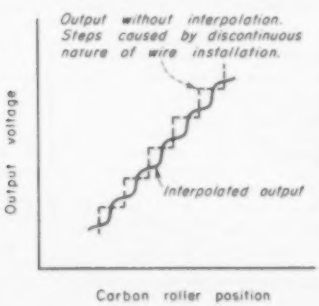
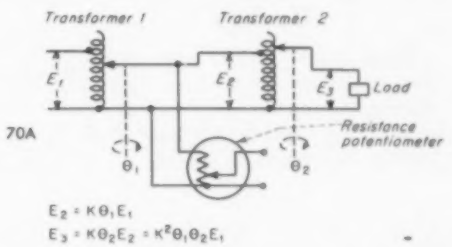
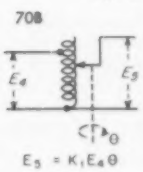

Output without interpolation. Steps caused by discontinuous nature of wire installation.
Interpolated output
Output voltage
Carbon roller position

Fig. 69—Effect of carbon roller interpolation on variable transformer output. There are no discontinuities in the smoothed curve, and the amplitude of the ripple is only about 20 percent that of the uninterpolated steps. This leads to infinite resolution.





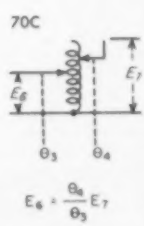


Fig. 70—Variable Transformer Circuits (A)—Variable transformers in a series chain. The high input impedance and low output impedance permit these units to be loaded directly on one another without an isolating booster amplifier. Also, additional heavy loading elements (resistance potentiometer) can be connected in the circuit. (B)—Voltage step up with a variable transformer. This arrangement is useful in circuit calibrating. The unit can step up E_4 for Θ maximum. Resistance potentiometers cannot be used in this application. (C)—A circuit for dividing one angular input, Θ_4, by another, Θ_3. The turns excited by E_6 vary linearly with Θ_3. There is a maximum E_6/Θ_3 that is determined by core saturation.

makes this device superior to resistance potentiometers in certain applications. The advantages gained are as follows:

1.—The carbon roller interpolates between turns so that infinite resolution is obtained, Fig. 69.

2.—This type construction improves contact life. As the roller wears, its diameter merely reduces in size.

3.—Radio interference generation is reduced by the smooth action of the carbon roller in making and breaking contact points.

4.—The conducting shaft of the carbon roller turns in a pair of grooves in the wiper arm. This gives a self-wiping contact from the roller to the external circuit.

Because of its toroidal construction, the inductive potentiometer has negligible resistance and leakage reactance in many applications. Thus, its performance approaches that of an ideal variable transformer and it can be heavily loaded without regulation, has a high input impedance, and negligible phase shift.

Typical application circuits that can be simplified by the use of a variable transformer are shown in Fig. 70. This device should be considered wherever resistance potentiometers are used and especially where the variable transformer's longer life or other special features will improve design.

Angle Transmission Devices

Many special purpose angle transmission devices are available. Factors affecting the selection of one type over another are: compactness, low shaft friction and minimum inertia.

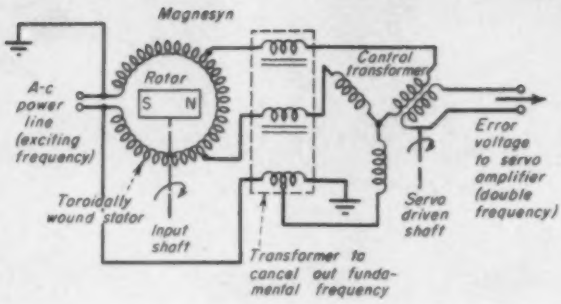


Fig. 71—Schematic of Magnesyn manufactured by Eclipse-Pioneer. It can be directly driven by a low torque transducer. Friction is less than 0.005 oz-in., and system accuracies of plus or minus 0.25 percent can be obtained. Double frequency reference voltage is required.

Magnesyn. This component, manufactured by Eclipse-Pioneer, can be used to replace a control synchro generator where a small torque is available from the input data transducer, Fig. 71. It consists of a toroidal coil wound on a laminated core. The rotor is a small permanent magnet.

The coil is excited by an alternating voltage and the system constants chosen so that the core is completely saturated at each peak of the excitation current. Because of the unsymmetrical saturation of the core when it is magnetically baised by the rotor flux, alternating second harmonic voltages can be tapped from three points of the coil. The relative values of these voltages depend on rotor position.

Leads from the tapped points are connected to a control transformer through a special transformer that bucks out voltages of the exciting frequency, and only passes the second harmonic voltages that are dependent on shaft position. A servo operating at double the exciting frequency is used to balance the control transformer. This is a disadvantage since a double frequency reference voltage is required.

Synchrotel. This Kollsman component has similar applications to the Magnesyn, but has a different principle of operation. In Fig. 72(A) is shown the electromagnetic circuit.

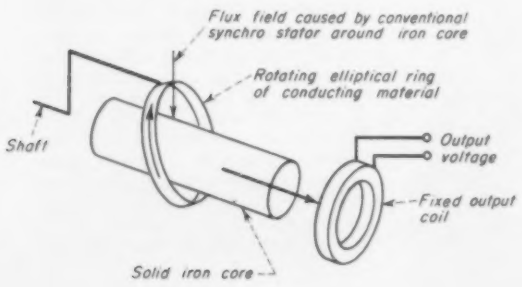
A conventional three legged synchro stator surrounds the fixed central iron core and generates a radial flux field that pulsates at line frequency. A skewed elliptical conducting ring is rotated so that it links the radial flux either with one polarity or another. Currents with a corresponding phase are generated in the ring.

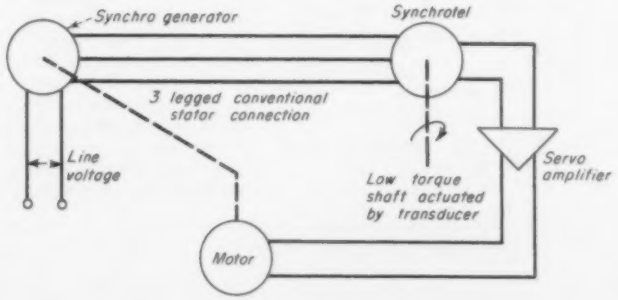
The current in the ring generates an axial flux component along the solid iron core which links the output coil and produces an output voltage. Just as in a control transformer, the output coil voltage is a measure of the magnitude and direction of the angular rotor displacement or error and can be used to actuate a servo. When driven by a data input transducer, Fig. 72(B), a special inverted servo arrangement is required.

Microsyn. This component is manufactured in several models having standard mechanical features, but differing as to winding and connection arrangements. The principal models are:

1. Torque generator which gives a torque that is proportional to the square of the exciting current or to the product of the currents in two exciting

Fig. 72(A)—Schematic of Synchrotel electromagnetic structure. Unit is manufactured by Kollsman Instrument Co. The low inertia, jewel mounted elliptical ring is the only rotating part. The distribution of conducting materal in the ring results in an accurate sinusoidal variation of output voltage with rotation from null. The accuracy is about 1 percent, with the principal design limitation being the difficulty of laminating the unconventionally shaped magnetic circuit. (B)—Inverted Synchrotel servo. The low torque shaft is directly coupled to a sensitive transducer. The output drives a servo motor which is coupled to a transmission generator. The fact the leads must be carried back to the generator makes this mode undesirable in conventional servos.


Flux field caused by conventional synchro stator around iron core
Rotating elliptical ring of conducting material
Shaft
Output voltage
Fixed output coil
Solid iron core



windings. The torque is constant over the specified angle of rotation of the rotor.

2. Signal generator which gives an a-c voltage varying linearly in amplitude with the product of the exciting current and the angular rotation of the rotor from a null position.

3. Elastic restraint generator which, for constant excitation, generates a linearly varying torque with displacement from the null. The torque varies as the square of the exciting current.

A computer for solving the differential equations of shaft dynamics can be constructed by combining these three components with inertial or viscous members on the shaft under consideration. The units can be used together to measure gyro drift (signal generator) and to give a correcting precessional torque (torque generator). The elastic restraint generator (variable spring) can be used on a rate gyro that generates a precessional torque varying with angular rate. By measuring the displacement of the elastic restraint generator with a signal generator, a rate voltage can be obtained. If the output of signal generators are interconnected, an accurate angle transmission system can be obtained, with a torque motor as the balancing device.

These units have light balanced rotors mounted on jewel bearings and will only operate over limited angles of rotation. Accuracies of 0.1 percent are possible. This is high for a torque device in this application.

Typical Closed Loop Application Circuits

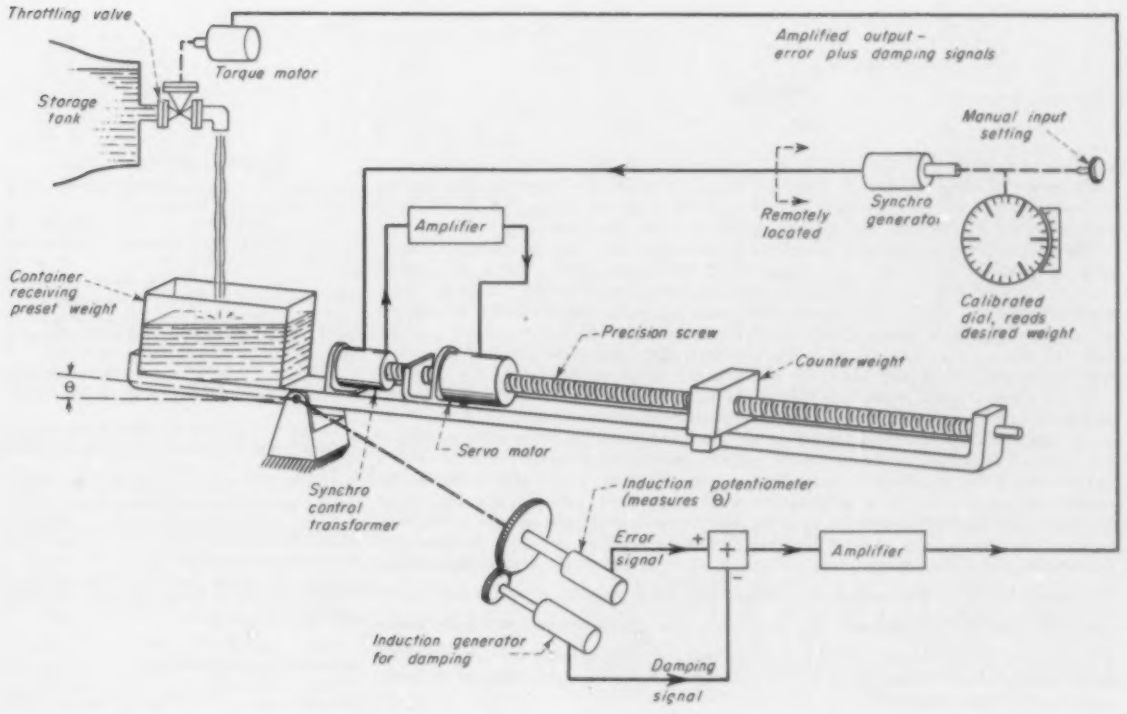


Fig. 73—AUTOMATIC WEIGHING DEVICE. Schematic diagram of a circuit used to accurately meter a specified weight of a liquid substance. The desired weight can be set at a remote location and two servo loops are used for controlling the weighing and metering equipment.

One servo is a conventional synchro transmission system that converts the set position of the remotely located calibrated dial to an accurately corresponding position of the counterweight along the drive screw. When the manual input is adjusted, the synchro generator develops an output voltage proportional in magnitude and phase to the dial setting.This voltage is fed to the synchro control transformer which generates an error signal that is proportional to the difference in angular position between the generator rotor and the control transformer rotor. This signal is amplified and drives the servo motor and screw until the output of the control transformer balances the output of the generator and the error is zero. The dial is calibrated so that its reading is the weight of liquid required to balance the counterweight.

When the counterweight is moved, the horizontal null setting of the beam is unbalanced and an error voltage is developed by the induction potentiometer. The magnitude of this error is proportional to Θ. The error, plus the induction generator damping voltage, is amplified and energizes the torque motor servo to regulate the flow of material into the receiving container. The damping voltage is added negatively and stabilizes the system since it is proportional to the rate of change of beam angular position. The system must be critically damped to prevent any overshoot since it is impossible to automatically remove liquid if the quantity in the container is allowed to exceed that required to balance the beam. This arrangement can be used for remote manual weighing, or as a component part of an overall process control system.

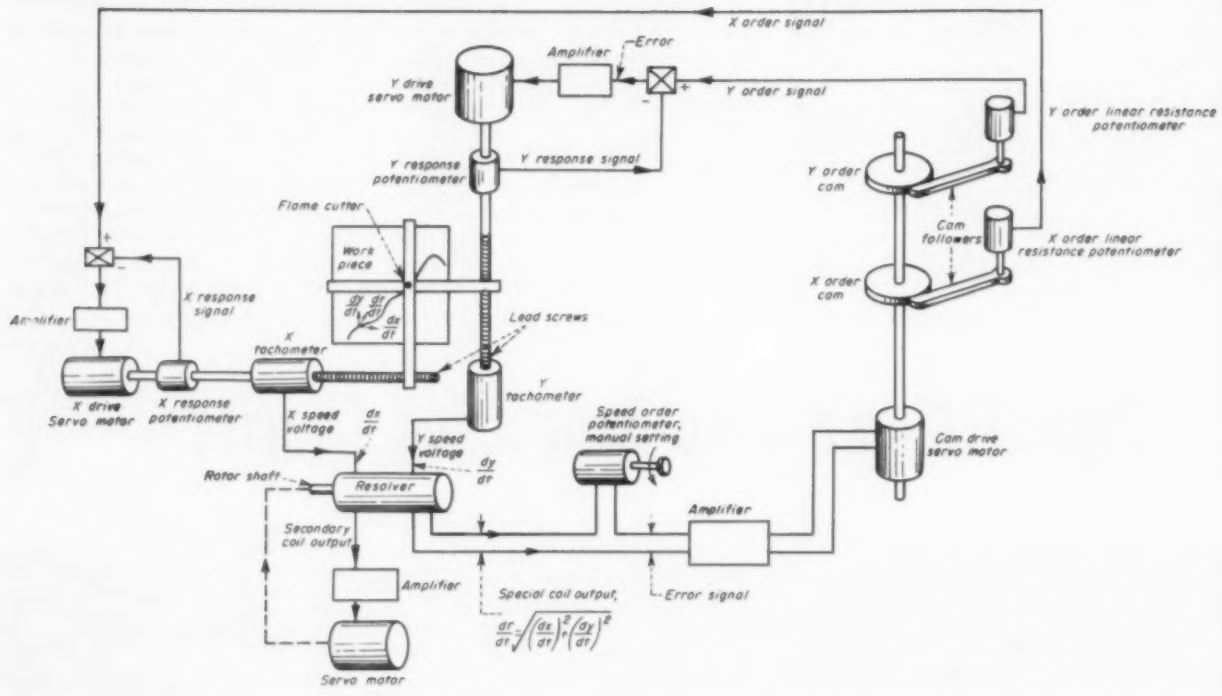


Fig. 74—FLAME CUTTING CONTROL. Arrangement for automatically cutting preset contours with a flame cutter. The system provides for cutting the proper contour and for maintaining constant cutting speed regardless of the shape of the contour. The control system can be divided into two parts in accordance with these functions.

The contour shaping system is controlled by two cams that contain the proper coordinate information to give the correct shape. The cam followers drive X and Y order linear resistance potentiometers which transmit signals to the X and Y lead screw drives. Each drive consists of a closed loop servo. The order signal is compared with a feedback voltage from the multi-turn response potentiometer and the difference or error is amplified. The drive motor is energized by the amplified signal and drives the lead screw and response potentiometer until the order signal equals the response signal.

In the cutting speed regulating circuit, the tachometers attached to the lead screws develop outputs proportional to the speed of rotation of the screws or to dx/dt and dy/dt in the coordinate system. These rate of change voltages are applied to the primary coils of a resolver. The output of the secondary resolver coils is amplified and used to drive a servo motor which positions the rotor (carrying the secondary coils) so as to reduce the resolver output to zero. Thus, this resolver servo loop simply positions the rotor in accordance with the dx/dt and dy/dt input signals. A special coil, with its axis perpendicular to the secondary coils, is wound on the rotor of the resolver. A voltage is induced in this special coil proportional to the vector sum of dx/dt and dy/dt, so that this voltage, $\frac{dr}{dt}$, is proportional to the instantaneous tangential cutting speed at any point on the contour. The signal, $\frac{dr}{dt}$, is compared with the voltage from a manually set speed order potentiometer, and the difference or error is amplified and used to energize the order cam servo motor. Thus, cutting speed can be maintained at any desired value by properly adjusting the speed order unit.

Type and Manufacturer of Components Shown on This Month's Cover

1.—Hydraulic servo control pump, Vickers, Inc., Division of Sperry Corp.
2.—Ten ganged plug-in potentiometer, Fairchild Camera and Instrument Corp., Potentiometer Division.
3.—Precision linear potentiometer, The Helipot Corp.
4.—Induction generator, Ford Instrument Co., Division of Sperry Corp.
5.—Synchro control transformer, Ketay Manufacturing Co.
6.—Telesyn synchro control transformer, Ford Instrument Co.
7.—Temperature compensated resolver, Ford Instrument Co.
8.—Combination induction motor and generator, Kollsman Instrument Co.
9.—Servo motor with gear head, Kearfott Company, Inc.
10.—Synchro control transformer, Kearfott Company, Inc.
11.—Combination induction motor and generator, Kearfott Company, Inc.
12.—Servo motor, Ketay Manufacturing Company.
13.—Solenoid operated magnetic clutch, Bolock Instrument Corp.
14.—Synchrotel, Kollsman Instrument Company.
15.—Five watt servo motor, Ford Instrument Company.

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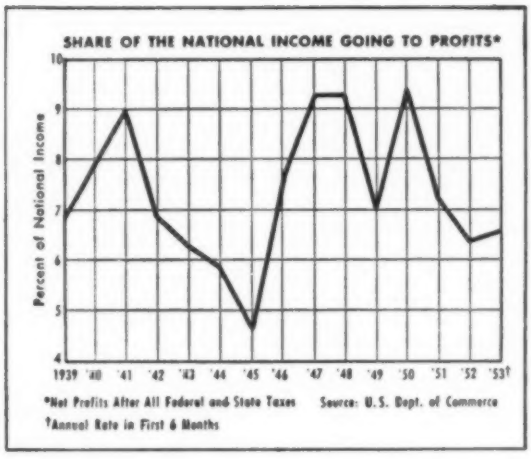
ACKNOWLEDGEMENT:

The author would like to thank the following concerns who supplied technical data and illustrations for this article: Arma Corp.; Borg Equipment Division, The George W. Borg Corp.; Eclipse-Pioneer Division, Bendix Aviation Corp.; Electric Indicator Company; Electro-Mec Laboratory; Fairchild Camera & Instrument Corp., Potentiometer Division; Galetronics, Inc.; The Gamewell Company; General Electric Company; G. M. Giannini & Company, Inc.; G. M. Laboratories, Inc.; The Helipot Corp.; Kearfott Company, Inc.; Ketay Manufacturing Corp.; Kollsman Instrument Corp.; Librascope, Inc.; Markite Corp.; Metron Instrument Company; Micromax Company; Minneapolis-Honeywell Regulator Company; Muirhead & Company, Ltd.; Reliance Electric & Engineering Company; Servomechanisms, Inc.; Servo-Tek Products Company; Technology Instrument Corp.; and Trans-Sonics, Inc. With special thanks to Julius Y. Kaplan of the Arma Corp. for advice on industrial applications.

The first of two articles on profits

PROFITS...How High Are They?


SHARE OF THE NATIONAL INCOME GOING TO PROFITS*
Percent of National Income
10
9
8
7
6
5
4
1939 '40 '41 '42 '43 '44 '45 '46 '47 '48 '49 '50 '51 '52 '53†
*Net Profits After All Federal and State Taxes
Source: U.S. Dept. of Commerce
†Annual Rate in First 6 Months

How high are profits? What is being done with them? This is the first of two articles designed solely to throw some factual light on these key economic questions.

One of the important economic developments of 1953 has been a substantial increase in the dollar volume of corporation profits from the level of 1952. But to answer the question "How high are profits?" we must also measure them: 1) by comparison with the record of previous years, and 2) as a share of the total national income. The term "profits," as used here, refers to profits *after taxes*. These are the only profits that can be paid to stockholders or retained for use in the business.

In the first six months of 1953, corporate profits *after taxes* were at an annual rate of $20.4 billion. This was higher than in the first half of 1952, but lower than in the full years 1948 or 1950, or in the first half of 1951. If allowance is made for the declining value of the dollar, this year's net profits for all corporations represent less purchasing power than those made five or six years ago.

Here is the record of profits over the years:

	Net Profits After Taxes of All U. S. Corporations	
	Billions of Dollars	
	Actual	In 1953 Prices
1929	8.4	14.6
1939	5.0	9.8
1947	18.5	22.1
1948	20.7	22.7
1949	16.3	18.3
1950	22.7	24.6
1951	20.1	19.7
1952	18.6	18.7
1953*	20.4	20.4

*Annual rate, first six months

The record shows that real profits have a little more than doubled since 1939. This increase, however, does not mean that corporations are doing exceptionally well. The entire national income has doubled since 1939. And our industrial plant is more than twice as large as it was in 1939. Therefore, profits have just about kept pace with industrial growth.

Return on Investment

How high are profits compared with sales, or compared with the stockholders' investment?

What is the rate of return to the people who have invested their savings in corporate business?

The table below shows that for the past three years the rate of return on both sales and investment has been substantially below the return achieved in earlier postwar years. The rate of return on stockholders' investment is higher now than it was in 1939. But this is primarily because today's profits are reported in terms of today's prices, whereas much of the investment in plant facilities is still carried on the books at prewar prices, which are substantially below the cost of replacement. The current rate of return, measured as a percentage of total corporate sales, is below prewar levels.

	Corporate Profits After Taxes	
	Per Cent of Total Sales	Per Cent of Stockholders' Equity *
1929	6.1	NA
1939	4.1	4.0
1947	5.3	14.8 average
1948	5.3	
1949	4.4	
1950	5.3	
1951	4.1	11.8
1952	3.6	10.3
1953#	3.7	10.8

* Manufacturing corporations only
NA Not available
Annual rate, first six months

In considering these figures, it should be remembered that they are averages for all corporations. Some companies make more than the average, and many make no profit at all. In every year since 1915 at least 25% of all corporations have operated at a loss. In 1939, 58% of all corporations were losing money. This year the figure will probably be at least 30%. The improvement since 1939 shows a much healthier economy. But it does not indicate that profits are easy to make.

How Big a Share of the Pie?

The most important single fact about profits is that they now represent a *smaller* share of national income than they have in past years of normal prosperity. For the past three years, profits have taken a smaller share of the pie than in 1939, and considerably smaller than in the early postwar years. Here, as the chart at the beginning shows, is the record:

	Corporate Profits After Taxes as a Percentage of National Income
1929	9.6
1939	6.9
1947	9.3
1948	9.3
1949	7.5
1950	9.4
1951	7.2
1952	6.4
1953*	6.6

*Annual rate, first six months

The main reason for the declining corporate share of national income is, of course, the increasing share taken by the federal government in the form of taxes. The wage earners' share is also higher than in 1939. But the really startling increase is in federal taxes. Taxes on profits now equal almost 8% of the national income, compared to only 2% in 1939.

Why This Is Important

It is important that these facts about profits and taxes be widely understood. At its next session, Congress must consider what to do about the emergency taxes on profits enacted after the outbreak of the Korean War. The so-called excess profits tax is scheduled to die on January 1, 1954. In the absence of new legislation, the rate of the corporate income tax will drop from 52% to 47% on April 1. Many factors, including the revenue needs of the government, must enter into the decision whether or not to reduce taxes. But one fact stands out clearly: By comparison either with past years or with the total national income, corporate profits today are relatively low.

* * *

The second article in this series will discuss what corporations do with their profits.

McGraw-Hill Publishing Company, Inc.

Simplified Analysis of Complex Vibration Problems

Based on the fundamental principles of the Mobility Method, the author presents an approach for solving multi-mass and other complex vibration problems that retains all of the advantages of the Mobility Method and also posesses a few additional ones as well.

O. C. BREWSTER
Consultant, Litchfield, Conn.

TO AVOID BEING OVERWHELMED by complicated differential equations, engineers have developed several specialized techniques for solving complex vibration problems. Among these are the Electrical Analogy, Rayleigh's Method, and the Mobility Method. See References on pg 166.

The last mentioned uses a term called "mobility" to describe the behavior of the three basic mechanical elements in a vibrating system: spring; resistance (viscous damper); and mass. In such a system, the mobility of each element—defined as its velocity divided by the force applied to it—is evaluated with the help of a special schematic diagram. From these, the displacement, velocity, and phase relationship for each element can be determined. Also, the mobility of the entire system, and thus such characteristics as natural frequency and critical damping, can be established without recourse to mathematics beyond algebra.

A shortcoming of this method, however, is that mobility is one of those mathematical abstractions that defy visualization. In practice, the resolution of a number of mobilities is not an intuitive process. Rather, it is one that must be learned by rote. It will be shown herein that force alone can be used as the operator, retaining all of the advantages of the mobility method plus gaining some additional ones.

The mobility technique accomplishes what it does by using the notation of complex quantities to describe rotating vectors which represent harmonic vibrations. In addition, the schematic diagrams set forth by a formal, but understandable code, the roles which all elements in the system play. It is the use of these two devices in conjunction with an operator that gives the method its value rather than the concept of mobility itself. Thus, the same results can be gained by using F alone, instead of

Table I—Nomenclature for Linear Systems

- s = linear displacement, in.
- v = linear velocity, in./sec.
- a = linear acceleration, in./sec.^{2}
- F = force, lb.
- m = mass, W/g, lb. sec.^{2}/in.
- W = weight, lb.
- g = acceleration of gravity, 386 in./sec.^{2}
- k = spring constant, lb./in.
- r = damping constant, lb. sec./in.
- t = time, sec.
- ϕ = phase angle, radians
- ω = angular velocity of harmonic motion, radians/sec.
- e = base of natural logarithms, 2.7183. . . .
- i $\sqrt{-1}$

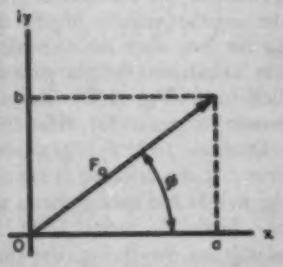
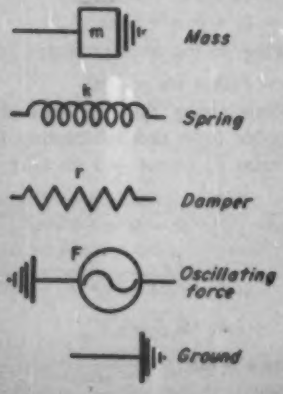


Fig. 1—Method of representing a vector with a complex coordinate system.

Table II—Symbols Used in Schematic Diagrams



v/F, or as one may determine for himself, any number of terms such F/s or $1/F$ are mathematically possible.

Space does not permit a review of the use of complex numbers for the mathematical study of vectors. It is sufficient to note that a vector drawn on complex co-ordinates as in Fig. 1 may be designated as F which here represents a force. This vector then describes a force of absolute magnitude F_o, that is rotated counter-clockwise by angle ϕ, and has a real component a measured on the abscissa and an imaginary component ib measured on the ordinate. It is equal mathematically to the sum of these components and can be expressed in a number of ways:

$$F = a + ib \quad (1)$$

$$= F_o(\cos\phi + i\sin\phi) \quad (2)$$

$$= F_o(\cos\omega t + i\sin\omega t)$$

$$= F_o e^{i\phi} = F_o e^{i\omega t} \quad (3)$$

Since the angle ϕ represents the instantaneous position of the vector, it can be expressed by $\phi = \omega t$, where ω is the angular velocity and t is the time from an arbitrary datum.

SCHEMATIC DIAGRAM. The schematic diagram is a simple but effective device. Each of the three elements, spring, damper and mass is represented by an individual symbol as shown in Table II. Each element has two terminals and each terminal must be connected to another element or to the ground. The only exception is that a mass is always grounded at its right hand terminal. All systems are assumed to have an impressed harmonic force, which is drawn at the left, grounded on its left terminal, and has its right terminal connected to the system. The diagram then proceeds from left to right until all the elements are shown in their proper relation. The value of the diagram is its clear portrayal of this relation which is not always apparent from a pictorial diagram of the system. Examples are shown in Figs. 2 to 4. For an exhaustive treatment of this subject as well as that of the use of complex numbers in this type of problem the reader is referred to the text by Freberg and Kemler.[4]

Determination of Forces

The value of the force vector involved with each mechanical element can be found readily. For a weightless spring, either tension or compression, the force, F_s, exerted by the spring is ks, where k is the spring constant and s is the displacement vector. Hence,

$$F_s = ks, \text{ where } s = s_o e^{i\omega t} \quad (4)$$

For a frictional resistance or damper where the friction is proportional to the velocity, as in a dashpot or a lubricated bearing, the force with which it resists motion is equal to the product of the damping constant r and the velocity. Thus,

$$F_r = rv$$

Since

$$v = \frac{ds}{dt} = \frac{d}{dt}(s_o e^{i\omega t}) = i\omega s_o e^{i\omega t} = i\omega s, \quad (5)$$

then

$$F_r = ir\omega s$$

The inertia resistance of a mass to a change of motion is

$$F_m = ma,$$

and

$$a = \frac{d^2s}{dt^2} = \frac{d^2}{dt^2}(s_o e^{i\omega t}) =$$

$$i^2\omega^2 s_o e^{i\omega t} = -\omega^2 s$$

Thus,

$$F_m = -\omega^2 ms \quad (6)$$

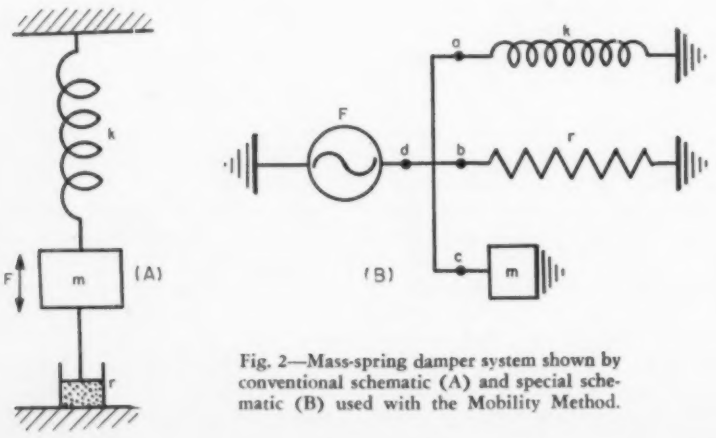


Fig. 2—Mass-spring damper system shown by conventional schematic (A) and special schematic (B) used with the Mobility Method.

SAMPLE PROBLEM. Even a simple problem will illustrate the use and advantages of the force-operator. Fig. 2(A) shows a mass m suspended on a coil spring having spring constant k with sliding viscous friction represented by a damper having constant r. Associated with the weight is an unbalanced dynamic force as a motor with an unbalanced rotor, exerting harmonic force F. The weight is so guided that motion is constrained to the vertical axis. The component of F along the vertical axis, that is, the force acting to displace the weight, is $F_o\cos\omega t$ and where F_o is the absolute magnitude of the unbalanced force, ω is the angular velocity of the motor and t the time since the eccentric axis of the unbalanced weight passed the vertical axis. Fig. 2(B) shows the schematic diagram for this system. The harmonic force F is grounded or anchored at the left and is connected to the weight and spring system at the right. Since F exerts force independently on the spring, the damper and the weight, they are connected in parallel as shown. Also the sum of the three resistance forces must be equal and opposite to the exciting force, thus, the algebraic sum of all forces in this isolated system must be zero at any instant. Hence,

$$F = F_a + F_b + F_c \quad (7)$$

$$= ks + ir\omega s - \omega^2 ms \quad (8)$$

Solving for the displacement:

$$s = F/(k + ir\omega - \omega^2 m) \quad (9)$$

Rearranging this in conventional complex form and substituting for F its value $F_o(\cos\omega t + i\sin\omega t)$:

$$s = \frac{F_o(\cos\omega t + i\sin\omega t)[(k-\omega^2 m) - ir\omega]}{(k-\omega^2 m)^2 + r^2\omega^2}$$

$$= \frac{F_o}{\sqrt{(k-\omega^2 m)^2 + r^2\omega^2}}[\cos(\omega t - \phi)$$

$$+ i\sin(\omega t - \phi)] \quad (10)$$

where $\phi = \tan^{-1}\dfrac{r\omega}{k-\omega^2 m}$

The two Eqs (9) and (10), represent the solution to the problem and

are equivalent to what would be obtained from the mobility method, or differential equations. From these equations, all characteristics of the motion of the mass can be derived. For example, if the denominator of Eq (9) is set equal to zero, solving for ω yields the natural frequency of the damped system:

$$-\omega^2 m + ir\omega + k = 0$$

From this,

$$\omega_{nd} = \frac{-ir \pm \sqrt{-r^2 + 4km}}{-2m}$$

$$= i\frac{r}{2m} \pm \sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2} \qquad (11)$$

Substituting Eq (11) into the basic equation $s = s_o e^{i\omega t}$, and assuming that r is relatively small

$$s = s_o e^{-\frac{rt}{2m}} e^{t\sqrt{\frac{k}{m}-\left(\frac{r}{2m}\right)^2}t}$$

$$= s_o e^{-\frac{rt}{2m}}\left(\cos\sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2}t\right.$$

$$\left. + i\sin\sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2}t\right) \qquad (12)$$

If the term under the radical is real, that is, if $k/m > (r/2m)^2$, Eq (12) defines a free harmonic vibration with initial displacement s_o, frequency

$$\sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2}$$

radians per second, and with a decreasing amplitude due to damping controlled by $e^{\frac{-rt}{2m}}$ which approaches zero as time t increases. The amplitude for any particular cycle or half cycle when $\cos\sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2}t$ equals 1 or —1—(that is, whenever the angle

$$\sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2}t$$

is an even or odd multiple of π) is $s = s_o e^{\frac{-rt}{2m}}$. If the term under the radical is zero or imaginary, i.e. if $k/m < (r/2m)^2$, the motion is no longer oscillatory since i would disappear from the exponent in

$$e^{i\sqrt{\frac{k}{m}-\left(\frac{r}{2m}\right)^2}t}$$

Note that when the radical is zero or imaginary the value of ω, the angular velocity of the vectors, as given by Eq (11) becomes a pure imaginary. This in itself shows that there is no real vector velocity; hence, no vibration. Thus, the critical damping constant r_c, the constant at or above which free harmonic vibration ceases, can be found. If $k/m - (r/2m)^2 = 0$ then $r = r_c$ and $r_c = 2\sqrt{mk}$. The undamped natural frequency ω_n of this system can be found from Eq. 11 by letting r equal zero (thus eliminating damping) and is found to be $\omega_n = \sqrt{k/m}$. Thus, from the denominator of Eq (9), equated to zero one may study the free vibration of the system which, being damped, is transient and soon disappears.

From Eq (10) the steady state vibration induced by harmonic force F can be analyzed.

In Eq (2), it was shown that the coefficient of the (cos + i sin) term represents the absolute magnitude of a vector. Thus, the maximum displacement, or amplitude, is:

$$s_o = \frac{F_o}{\sqrt{(k - \omega^2 m)^2 + r^2\omega^2}} \qquad (13)$$

The ($\omega t - \phi$) term shows that the displacement vector lags behind the force vector by angle ϕ, the magnitude of which depends largely upon the damping constant and the value ($k - \omega^2 m$). Note that if $k - \omega^2 m = 0$, that is, forced frequency equals natural undamped frequency, the displacement lags the force by 90 deg. On the other hand, if r is small, force and displacement are more nearly in phase. Other relationships can be found and the complete picture of the vibration be drawn. These factors are, of course, exactly the same as those found by solving the problem by either differential equations or the mobility method. To compare the three methods, the other solutions will be outlined.

Comparison With Differential Equations

The solution by differential equation deals only with the real components of forces and displacements. The instantaneous value of an harmonic force is then $F_o\cos\omega t$ and that of a linear displacement may simply be designated as x. The forces with which each of the elements resist displacement are:

Spring $F_s = kx$ (14)

Damper $F_r = rv = r\frac{dx}{dt}$ (15)

Mass $F_m = ma = m\frac{d^2x}{dt^2}$ (16)

As in the solution already given, the sum of the forces in this example are equal and opposite to the external exciting force. Hence

$$F_m + F_r + F_s = F_o\cos\omega t$$

or

$$m\frac{d^2x}{dt^2} + r\frac{dx}{dt} + kx = F_o\cos\omega t \qquad (17)$$

The solution of this linear differential equation consists of two parts, the *particular* solution related to the right hand member and the *general* solution found by equating the left hand member to zero. The *complete* solution is the sum of the particular and general solutions. The method of solving such equations is beyond the scope of this article. The particular solution of this equation is

$$x = \frac{F_o\cos(\omega t - \phi)}{\sqrt{(k - m\omega^2)^2 + r^2\omega^2}} \qquad (18)$$

where $\phi = \tan^{-1}\frac{r\omega}{k - m\omega^2}$

which is identical to the real part of Eq (10). The general solution of Eq (17) is

$$x = x_o e^{\frac{-rt}{2m}}\cos\sqrt{\frac{k}{m} - \left(\frac{r}{2m}\right)^2}t,$$

approximately, when r is relatively small and $k/m > (r/2m)^2$. This is idential to the real part of Eq (12) which describes the free transient vibration. Thus the algebraic method gave the complete solution of the differential equation, both particular and general, without even having the differential equation written down although examination will show that Eqs (8) and (17) are, in effect, almost identical. In this case, the solution of the differential equations is relatively simple. With more complicated vibrating systems the solution by differential equations becomes involved.

(continued on next page)

Solution by Mobility Method

The mobility method applied to this problem is more involved than the force vector method. The "mobility" or v/F of each element must be found:

Spring, $F_a = ks$;

$$v = \frac{ds}{dt} = i\omega s \tag{19}$$

Mobility of spring is

$$Z_a = v/F_a = i\omega/k \tag{20}$$

Damper, $F_b = rv$; $Z_b = v/rv = 1/r$ (21)

Mass, $F_c = ma$; $a = \frac{d^2s}{dt^2} = -\omega^2 s$;

$$Z_c = v/F_c = -i\omega s/m\omega^2 s = 1/im\omega \tag{22}$$

For elements in parallel, the mobility Z of the entire system, which is the mobility of the force F, is equal to the reciprocal of the sum of the reciprocals of the individual mobilities. Thus,

$$Z = \frac{1}{\frac{1}{Z_a} + \frac{1}{Z_b} + \frac{1}{Z_c}} \tag{23}$$

Substituting the values of Eqs (20) to (22) and reducing the equation to proper complex form:

$$Z = \frac{r\omega^2 + i\omega\,(k - m\omega^2)}{(k - m\omega^2)^2 + r^2\omega^2} \tag{24}$$

Since $Z = v/F$ and since $v = i\omega s$, then

$$Z = i\omega s/F \tag{25}$$

Substituting this value of Z into Eq (24) and solving for s:

$$s = \left(\frac{F}{i\omega}\right) \frac{r\omega^2 + i\omega\,(k - m\omega^2)}{(k - m\omega^2)^2 + r^2\omega^2}$$

$$\text{or } s = F\,\frac{(k - m\omega^2) - ir\omega}{(k - m\omega^2)^2 + r^2\omega^2} \tag{26}$$

Eq (26) can also be written in the form:

$$s = F/(k - m\omega^2 + ir\omega) \tag{27}$$

which is identical to Eq (9), which was found as the first step after writing the basic equation Eq (8) for the force vector method. From this point the analysis by the two methods is the same. Eq (9) was derived by a simpler and more direct process than that required for either Eq (26) or (27) and illustrates the simplification claimed for this method.

Elements in Series

The example just presented was for elements in parallel. For elements arranged in series, the procedure is modified. Fig. 3(A) shows a system of three springs and two weights; the schematic diagram is given in Fig. 3(B). The subsystem m_2 and k_3, with spring k_3 and mass m_2 in parallel, is in series with spring k_2. This in turn, is in parallel with mass m_1 and spring k_1. Working from the right toward the left:

$$F_e = F_a + F_b \tag{28}$$

Determining the values of forces as before, Eqs (4-6), and substituting in Eq (28)

$$F_e = s_2\,(k_3 - m_2\omega^2) \tag{29}$$

The force F_e is also equal and opposite to the force exerted on point e by the spring k_2 which is equal and opposite to the force exerted by the same spring at point f. The spring force F_{fe} is the product of the spring constant k_2 and the net compression $(s_1 - s_2)$, that is, the net displacement of its ends. Hence

$$F_f = F_{fe} = F_e \tag{30}$$

In other words, the forces on elements in series are equal. Substituting the values for force in Eq (30)

$$F_f = k_2\,(s_1 - s_2) = s_2\,(k_3 - m_2\omega^2) \tag{31}$$

Solving for s_2 in terms of s_1:

$$s_2 = \frac{k_2\,s_1}{k_2 + k_3 - m_2\omega^2} \tag{32}$$

Using this value in the second term of Eq (31):

$$F_f = k_2\left(s_1 - \frac{k_2\,s_1}{k_2 + k_3 - m_2\omega^2}\right)$$

$$= \frac{k_2 s_1\,(k_3 - m_2\omega^2)}{k_2 + k_3 - m_2\omega^2} \tag{33}$$

Forces F_d, F_e and F_f are in parallel and their sum is equal to F_g or F:

$$F = F_g = F_d + F_e + F_f$$

$$= k_1 s_1 - m_1\omega^2 s_1 + \frac{k_2 s_1\,(k_3 - m_2\omega^2)}{k_2 + k_3 - m_2\omega^2} \tag{34}$$

Solving for s_1:

$$s_1 = F\,(k_1 + k_2 - m_2\omega^2)\Big/\Big[\omega^4 m_1 m_2 - \omega^2[m_1\,(k_2 + k_3) + m_2\,(k_1 + k_2)] + k_1 k_2 + k_1 k_3 + k_2 k_3\Big] \tag{35}$$

It is noteworthy that, up to this point, the term i has been absent since it occurs only in the expression for damping force which is not used in this problem. Inasmuch as damping, while never wholly absent, is small enough to be neglected in many applications, this is a real advantage of this method over the mobility method, in which i occurs in all elements except damping.

To complete the analysis, the value $F_o\,(\cos\omega t + i\sin\omega t)$ can be inserted

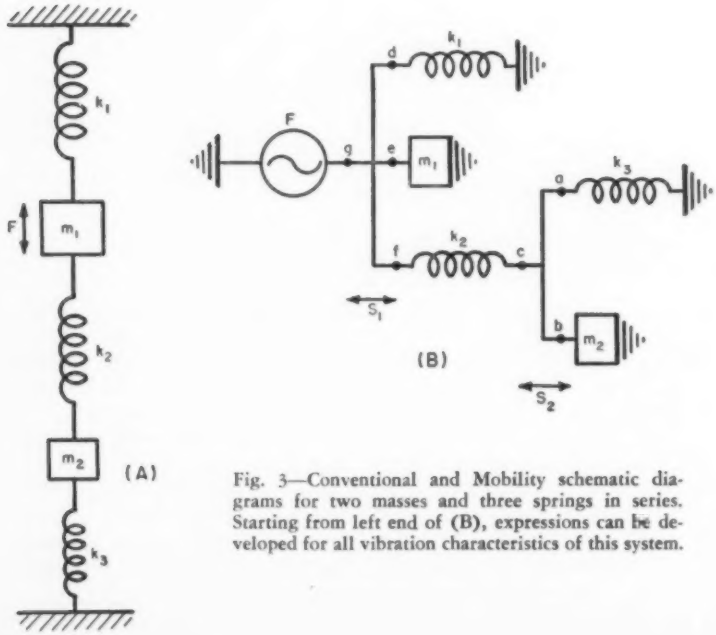


Fig. 3—Conventional and Mobility schematic diagrams for two masses and three springs in series. Starting from left end of (B), expressions can be developed for all vibration characteristics of this system.

in Eq (35) in place of F. This shows at once that the steady state amplitude s_{10} is given by Eq (35) with F_o substituted for F. If the denominator of Eq (35) is equated to zero, ω represents the natural frequency of the system and since ω will have two real positive values, the system vibrates in two modes and will have two critical speeds. At a point between these critical speeds s_1 becomes zero; this occurs when the term in parenthesis in the numerator of Eq (35) becomes zero. The displacement is either in phase with the force or 180 degrees out of phase, depending on whether the frequency of the forced vibration is immediately below or above a critical speed. The motion of mass m_2 can be determined from Eq (32) by substituting therein the value found for s_1. Full interpretation of the equations of motion obtained can then be carried out in the conventional manner.

The same equations can be found by the mobility method but with greater effort. Since mobilities in series are directly additive, the expression for Z will be:

$$Z = \frac{i\omega s_1}{F} = \frac{1}{\frac{1}{Z_d} + \frac{1}{Z_s} + \frac{1}{Z_{fc} + \frac{1}{\frac{1}{Z_a} + \frac{1}{Z_b}}}} \qquad (36)$$

Substituting the values of the individual mobilities into this equation will reduce it to an expression identical to Eq (35). The displacement of mass m_2 which is s_2 may be found by working back through the system. It may be shown that

$$s_1 = \frac{Z_a Z F}{i\omega Z_f} . \qquad (37)$$

which on substitution of the values for mobility reduces to an equation identical with Eq (32).

Table III—Equivalent Terms in Torsional Systems

	LINEAR TERM	ANGULAR TERM
Displacement	s = in.	θ = radians
Force	F = lb. force	T = in. lb. torque
Mass	m = lb. sec.²/in.	I = lb. in. sec.², mass moment of inertia
Spring constant	k = lb./in.	k_t = lb. in./radian
Damping constant	r = lb. sec./in.	r_t = lb. in. sec./radian
Velocity	$\frac{ds}{dt}$ = in./sec.	$\frac{d\theta}{dt}$ = radians/sec.
Acceleration	$\frac{d^2s}{dt^2}$ = in./sec.²	$\frac{d^2\theta}{dt^2}$ = radians/sec.²

Torsional Systems

The application of this method to the angular vibration of shafts and masses subject to harmonic torsional excitation is simple and involves only the substitution of the equivalent angular term in the appropriate linear expression as shown in Table III. The torque exerted on the primary elements resulting in motion is used as the operator instead of the force as in the case of linear motion. Torque is found in much the same manner as F. Thus:

Basic harmonic motion

$$\theta = \theta_o e^{i\omega t} = \theta_o (\cos \omega t + i \sin \omega t) \qquad (38)$$

Torque of twisting shaft

$$T_s = k_t \theta \qquad (39)$$

Torque of damper

$$T_r = r_t \frac{d\theta}{dt} = i r_t \omega \theta \qquad (40)$$

Torque of mass

$$T_m = \frac{I d^2\theta}{dt^2} = -I\omega^2\theta \qquad (41)$$

The similarity between these expressions and Eqs (4), (5) and (6) is apparent.

SCHEMATIC DIAGRAMS. Schematic diagrams for torsional systems are constructed in almost the same manner as those for linear systems. The only difference is that terms T, k_t, r_t, I and θ are substituted for their corresponding factors F, k, r, m and s. One modification, introduced by Binder[2], applies to the method of representing gears and is very helpful. Since the motion is oscillatory, a pair of gears can be represented by a weightless lever, having no backlash. A simple example will illustrate.

EXAMPLE OF TORSIONAL SYSTEM. A simple arrangement of a rotating mass I_1, excited by harmonic torque T, of frequency ω radians per second is shown in Fig. 4(A). Through a pair of gears having n_1 and n_2 teeth, respectively, mass I_2 is also vibrated, the torque being transmitted to it through a shaft having a torsional spring constant k_t. For simplicity the gears are assumed to be weightless.

The schematic diagram, Fig. 4(B), is constructed by starting with T, grounded at the left and proceeding as before. T operates on mass I_1 and the shaft k_t in parallel, being transmitted to the shaft by the lever representing the gears as shown. The lever is so arranged that it transmits force and motion to the shaft as do the gears. That is, a displacement of θ radians of I_1 results in a displacement of $(n_1/n_2)\ \theta$ radians of the shaft in both the actual case and in the schematic diagram where *angular* displacement is depicted as a *proportional linear* displacement. Similarly the torque on the shaft is $(n_2/n_1)\ T$ and in the schematic diagram it is the same.

The solution is straightforward and quite similar to that for the linear system. Starting with the system at the

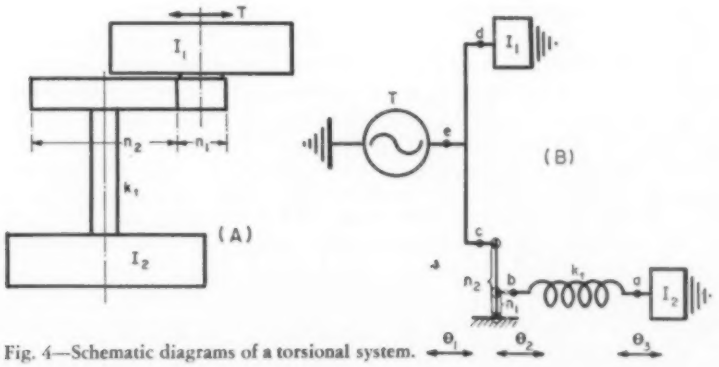


Fig. 4—Schematic diagrams of a torsional system.

right of the lever in Fig. 4(B), the spring torque and inertia torque, being in series, are equal. Hence

$$T_b = T_{ba} = T_a = k_t(\theta_2 - \theta_3) = -I_2\omega^2\theta_3 \quad (42)$$

Solving for θ_3,

$$\theta_3 = \frac{k_t\theta_2}{k_t - I_2\omega^2} \quad (43)$$

Substituting this value of θ_3 in the $k_t(\theta_2 - \theta_3)$ term of Eq (42)

$$T_b = \frac{-k_tI_2\omega^2\theta_2}{k_t - I_2\omega^2} \quad (44)$$

By inspection of the lever system it is evident that

$$T_b = \frac{n_2}{n_1}T_a \quad (45)$$

and

$$\theta_2 = \frac{n_1}{n_2}\theta_1 \quad (46)$$

Substituting these values in Eq (44)

$$\frac{n_2}{n_1}T_a = -\left(\frac{n_1}{n_2}\right)\frac{k_tI_2\omega^2\theta_1}{k_t - I_2\omega^2}$$

or

$$T_a = -\left(\frac{n_1}{n_2}\right)^2\frac{k_tI_2\omega^2\theta_1}{k_t - I_2\omega^2} \quad (47)$$

The torque at point c and that at point d are in parallel and are therefore added to determine the torque at point e or the exciting torque T:

$$T = T_e = T_d + T_a = -I_1\omega^2\theta_1 - \left(\frac{n_1}{n_2}\right)^2\frac{k_tI_2\omega^2\theta_1}{k_t - I_2\omega^2}$$

or

$$T = \frac{\left\{I_1I_2\omega^4 - \omega^2k_t\left[I_1 + \left(\frac{n_1}{n_2}\right)^2I_2\right]\right\}\theta_1}{k_t - I_2\omega^2} \quad (48)$$

Solving for θ_1:

$$\theta_1 = \frac{T(k_t - I_2\omega^2)}{\omega^4I_1I_2 - \omega^2k_t\left[I_1 + \left(\frac{n_1}{n_2}\right)^2I_2\right]} \quad (49)$$

As in linear systems, the natural frequency of vibration is found by equating the denominator of Eq (49) to zero, whence

$$\omega_n = \sqrt{\frac{k_t\left[I_1 + \left(\frac{n_1}{n_2}\right)^2I_2\right]}{I_1I_2}} \text{ rad/sec} \quad (50)$$

Up to this point i has been absent because of the absence of damping. However, it must be noted that $T = T_0(\cos\omega t + i\sin\omega t)$. Substituting this in Eq (49):

$$\theta_1 = \frac{T_0(k_t - I_2\omega^2)}{\omega^4I_1I_2 - \omega^2k_t\left[I_1 + \left(\frac{n_1}{n_2}\right)^2I_2\right]} \times (\cos\omega t + i\sin\omega t) \quad (51)$$

The amplitude of vibration of mass I_1 is then given by the coefficient of the $(\cos\omega t + i\sin\omega t)$ term. The amplitude θ_{10} of the mass I_2 can be found from Eq (43) in conjunction with Eqs (46) and (49) and all of the details of performance of the system can be determined. It is apparent that the displacement is either in phase with the torque or 180 deg out of phase depending on whether the expression for θ_{10} is positive or negative. Thus, except for the modification to permit the interpretation of gears, the solution of torsional problems is almost identical with that of linear problems and simplified to the same extent by using the force-operator.

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Vibration Pickup Calibrator

AN INSTRUMENT that calibrates vibration pickups and accelerometers rapidly and reliably has been devised by the National Bureau of Standards at the request of the Navy Bureau of Ships. The device operates on the principle of the mutual inductance transducer, originally developed by the Bureau to measure small displacements and since applied in a number of NBS measurement instruments. The instrument has an accuracy of five percent over wide frequency and amplitude ranges, and can be standardized using a calibrated displacement such as that provided by a precision dial gage.

In recent years, as use of vibration pickups for simultaneously monitoring a large number of points has increased, the calibration problem has become more difficult. One complication: the higher frequency components of vibration and resonant properties of the pickups interfere with analysis of the problem. Many of the calibration techniques now in use are limited in bandwidth and are difficult to standardize. Others require tedious point-by-point measurement and involve a considerable problem in data reduction. The NBS instrument was designed to overcome these deficiencies.

The vibration sensing element of the NBS instrument is a stable noncontacting displacement transducer of mutual-inductance type. The transducer uses the principle that the field surrounding a coil energized with alternating current will induce current in a nearby coil. The amount of current thus induced can be controlled by placing a conducting shield at various distances from the latter coil.

In the Bureau's calibrator, vibration of a non-magnetic conductive surface with respect to a probe containing the two coils and a carrier detector for the secondary winding generates an a-c component of output voltage proportional to the amplitude of vibration. In normal use of the instrument, this a-c component is measured by means of a stable vacuum-tube voltmeter, producing a reading proportional to the amplitude of vibration. It will respond to frequencies from 10 to 20,000 cps and amplitudes from 10 microinches to 0.01 inch.

The instrument is standardized by chopping the detected d-c voltage increment produced by a standard mechanically measured displacement change — 0.02 inch — into a square wave. Fed into the same a-c peak-to-peak voltmeter on the 0.01 inch range, the square wave is equivalent to a 0.01 inch peak amplitude of vibration.

The choice of a displacement as an absolute standard for the instrument was made primarily because of the ease with which it can be reproduced without special equipment.

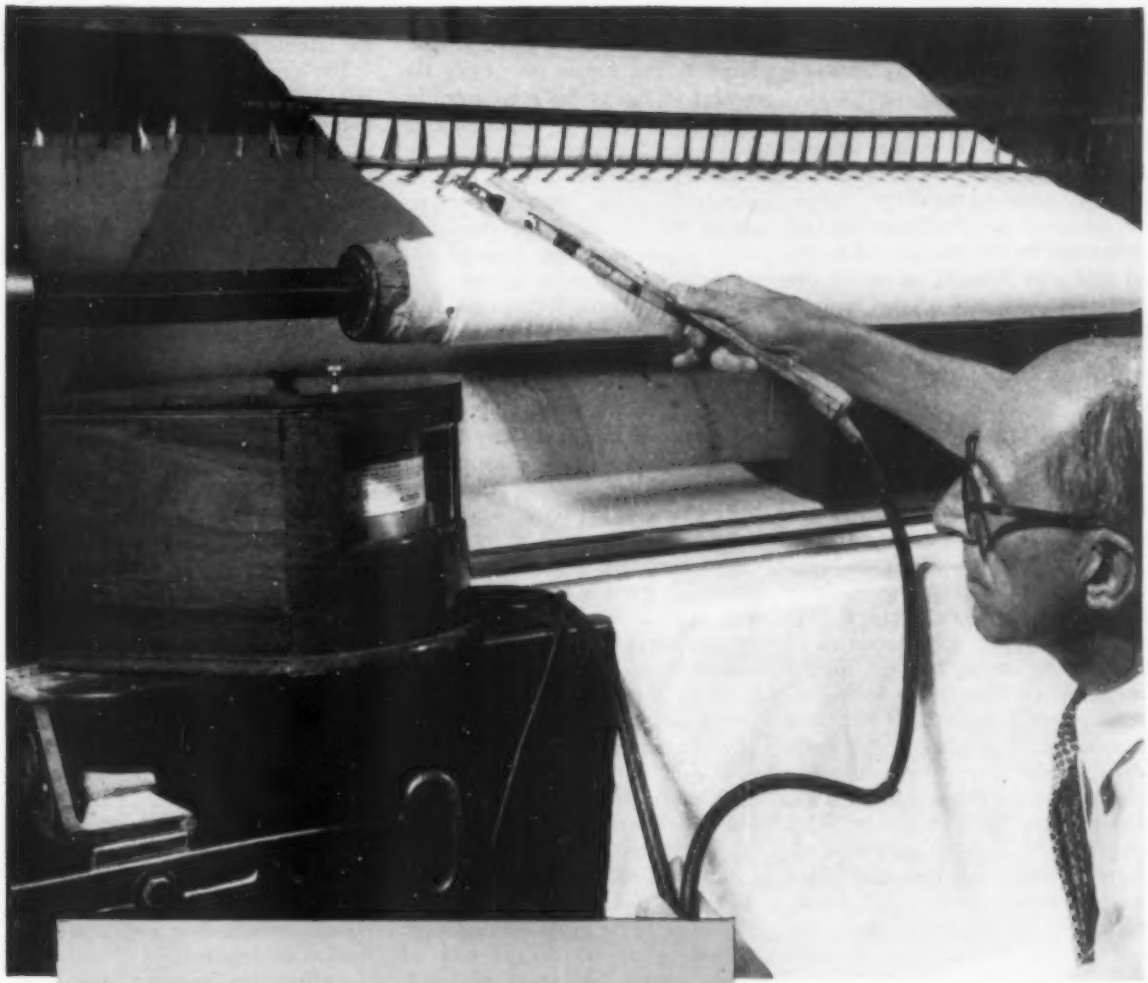

Fig. 1—Tufted type induction neutralizer on nylon fabric rewinder. An electrostatic voltmeter and a voltage probe are being used to locate the correct position of the neutralizer bar for optimum discharge.

Electrostatic Neutralizers

Second of two articles concerned with the application of electrostatic neutralizers. A method of locating neutralizers is described in addition to discharge characteristics and safety considerations of typical units

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THE FUNDAMENTALS of the generation and control of static electricity in industrial processing machinery together with the operating principles of the various types of commercially available electrostatic neutralizers were covered in Part I of this article. (See *Product Engineering*, October 1953, page 177). A major factor in the selection of the proper neutralizer is the discharge characteristic, which is a measure of the rate of ionization as

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it varies with stock potential. This has been determined for high voltage and radioactive pre-ionizing units and for induction units.

If the voltage between the electrified stock and ground is maintained constant at any desired value by continuously replacing the electric charges on the stock as rapidly as they are neutralized by the ions created in the air from the ionizing action of the neutralizer, the rate of this replacement of electric charges on the stock is a measure of the discharge effectiveness of the neutralizer. Since this rate of replacement is an electric current, the direct-current discharge can be determined for several values of constantly maintained voltage from stock to ground and the results plotted to give a characteristic discharge curve.

Two typical characteristic discharge curves for high voltage pre-ionizing neutralizers are shown in Fig. 2 (A). Each curve applies for a condition of constant a-c supply voltage to the transformer. The lower portion of these curves is practically linear since the number of ions, and consequently the discharge current required varies directly with the potential of the stock. However, the supply of ions created in the air by the high voltage neutralizer is by no means unlimited, and as the stock potential increases, the number of ions in the ambient air finally becomes insufficient to cause complete neutralization.

At this point, the number of ions and discharge current approach a constant value. For the performance characteristics shown in the figure, the neutralizer operating at the higher voltage, curve *Y*, can supply over twice the number of ions of that represented by curve *X*. Thus, on the basis of ionizing facility and discharge effectiveness, the neutralizer represented by *Y* is to be preferred to the neutralizer represented by *X*. However, based on safety requirements, the higher ionizing facility may not be the more desirable neutralizer as it may cause hazardous sparks or shocks and otherwise prove unsatisfactory.

If the stock potential is twice the potential at which the neutralizer reaches its maximum constant ionization condition, then the electrification on the stock will only be reduced by half. This situation occurs when high voltage units are used to neutralize highly electrified stock or when the processing speed is unusually high. In these applications, a second or follow-up neutralizer is sometimes used, located a few inches after the first.

Stock electrified to any voltage lower than that at which the discharge current reaches its maximum can be fully neutralized. However, whether complete neutralization can be attained also depends on several factors: the type of neutralizer and its proper location with respect to the electrified stock; the position of the neutralizer in relation to the grounded processing machine elements; the presence of nearby grounded structural parts which divert the electric field; and the operation of the high voltage neutralizer equipment within the recommended performance specifications of the manufacturer.

The number of ions formed in the space between a radioactive neutralizer and the electrified stock, while substantially of constant value, is only a small percent of the constant ionization derived from the better types of high voltage neutralizers. Thus, the discharge current for radium and polonium neutralizers also follows the form of the saturation curve, Fig. 2 (B), but the curvilinear section occurs at a low voltage compared to that of effective high voltage units.

The curve *Q* represents the discharge characteristic for conventional radium neutralizers and curve *R* for conventional polonium neutralizers. These show that the alpha radiation does not ionize the air enough to neutralize stock electrified above a relatively low voltage. For example, measurements on rewinding textile stock with a potential of 30,000 volts to ground demonstrated that a radium neutralizer only reduced this electrification to about 20,000 volts.

While this performance seems inadequate, these units possess certain compensating advantages. Their small cross-section makes them useful where space limitations preclude the use of high voltage neutralizers. Also, they are used in very low electrification applications where short lengths of neutralizers are required.

Unlike pre-ionizing neutralizers where the ionization is practically constant regardless of whether the stock is electrified or not, induction neutral-

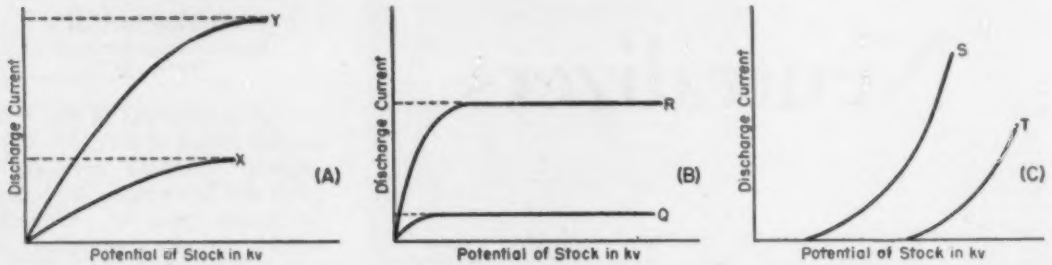


Fig. 2—Discharge characteristics of various types of neutralizers. In (A) is shown the discharge properties of two high voltage neutralizers each with a constant supply voltage. The neutralizer represented by curve *Y* has twice the ionizing potential of that represented by *X*. Of the radioactive types, (B), the polonium neutralizers, curve *R*, exhibit a much greater ionizing potential than the radium neutralizers, curve *Q*. Note that while the threshold of ionization of the high-voltage and radioactive neutralizers is low, the ionizing potential is limited. In contrast the induction neutralizers, (C), start ionizing at a few hundred volts but have unlimited ionizing potential. The threshold of ionization of the tufted type, curve *S*, is lower than that of the pack type, curve *T*.

izers are energized only when the stock is electrified. A well designed unit of this type, using tufts of wire bristles spaced along a treated wooden bar, starts ionizing the intervening air at only a few hundred volts and at the same time, possesses unlimited facilities for ionization.

The discharge characteristics of induction neutralizers are illustrated in Fig. 2 (C). The curve *S*, with its low threshold voltage for discharge, shows the advantages of the tufted type neutralizer. The curve *T*, with a higher threshold voltage, represents the characteristics of the strip type induction neutralizer with its continuous pack of wire bristles held in a metal backing frame. The starting voltage for ionization as required by these latter units ranges from 8,000 to 13,000 volts for normal spacings of 1 and 1½ in. between the ionizing points and the electrified stock.

The tufted type induction neutralizer effectively neutralizes to a residual value of only a few hundred volts regardless of how high the uncontrolled voltage may be. For most industrial applications, this residual voltage is below the level of potential fire or explosion hazards from spark ignition.

The effectiveness of an induction neutralizer depends on the variables encountered in each individual installation. For web type stock of high dielectric quality, like newspaper, plastic-film and rubber, that is highly electrified and operates at top industrial speeds, the tufted type induction unit will perform as well, or better than, the high voltage pre-ionizing units.

In the basic operations of the textile industry, the raw product has a filmy and web-like composition, and the presence of even slight electrification will cause imperfect processing. For example, webs wrap around and jam rolls while roving and yarn balloon into component fibers. High voltage pre-ionizing neutralizers or radioactive neutralizers are used in this application since they can completely neutralize the low potential electrification that develops. Induction neutralizers cannot be used in these operations since they are not capable of fully discharging the stock and, in addition, may cause fouling of the filmy web.

In Fig. 3 is shown a high voltage neutralizer discharging electrified cotton web as it is drawn off a carding roll, while Fig. 4 shows a radioactive unit used to neutralize yarn.

A comparison of the discharge characteristics of the three common types of industrial neutralizers is shown in Fig. 5. These curves represent approximate relative magnitudes.

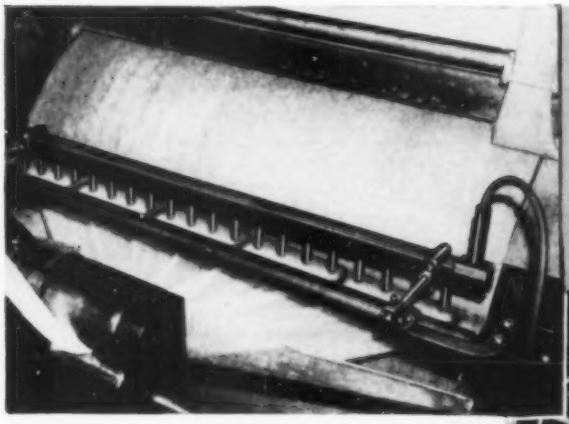
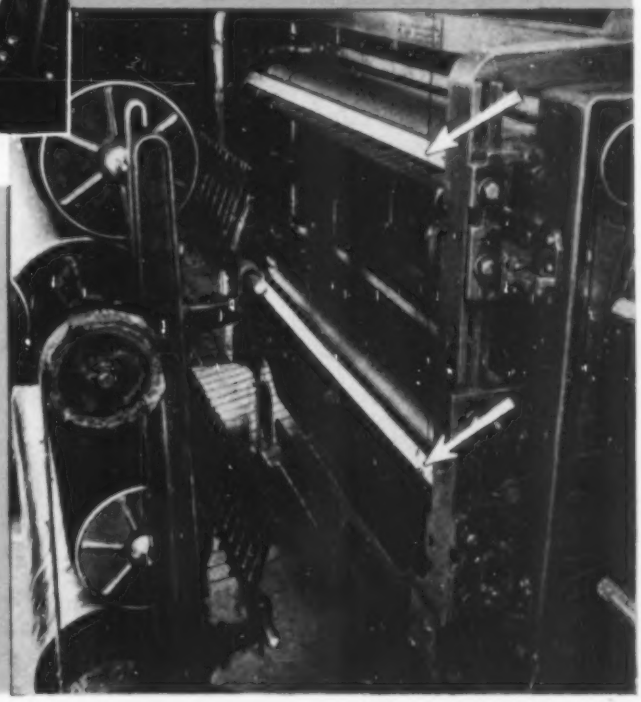


Fig. 3—High voltage neutralizer discharging the low electrification of filmy cotton web on a textile processing machine. This type neutralizer is well suited to this application.

Fig. 4—Fully automatic frames using radium neutralizers to discharge the low electrification. Similar to Fig. 3 in that residual voltage must be reduced to a very low level.



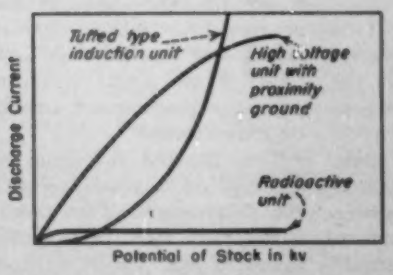


Fig. 5—Comparison of discharge characteristics for three types of neutralizers. Curves show the relative magnitude of the ionizing potential and threshold of ionization of the various units. While the tufted type induction unit is widely used, each type neutralizer is useful in specific applications.

Fig. 6 (Above)—Testing a high voltage preionizing neutralizer by the one hand safety rule. This method limits the possible shock effect to one hand. Units that give more than a slight shock are unacceptable.

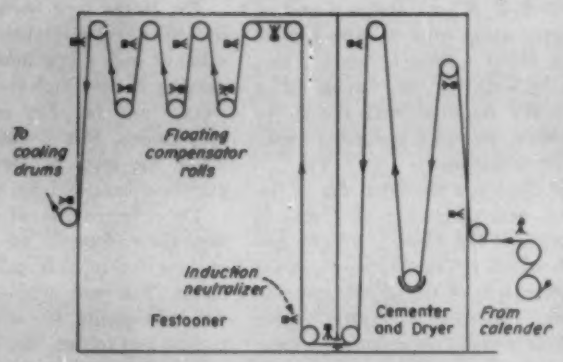
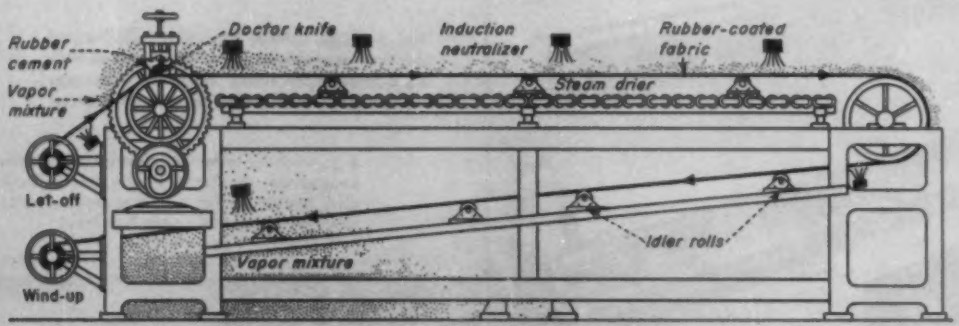


Fig. 7—Festoon type dryer completely equipped with tufted type induction neutralizers. Units are mounted after the breakaway point from each roll. This is representative of the number of neutralizers required on a complicated processing machine.

Fig. 8 (Below)—Rubber spreader for coating fabric. Inflammable mixture causes fire and explosion hazard if static electrification on the stock is not controlled. Tufted type neutralizers are shown in the required locations to reduce the static potential.



Choosing a Safe Neutralizer

The safety factors of neutralizer units should be considered since shock hazards from high voltage units can cause involuntary muscular responses which lead to personal injury.

Tests for determining safety from electric shock are made after the neutralizing equipment is properly connected and energized (transformer-energized type) although they do not have to be made on the actual machine. In testing the neutralizer for sparks and spark intensity, Fig. 6, the fingers of one hand only should be used.

The simultaneous touching of the fingers to the ionizing points and the grounded parts should not cause flinching or muscular response.

If preliminary tests disclose little shock reaction, the test should be repeated after wetting the tips of the contacting fingers to improve the conductivity of the skin.

If the electric shocks cause severe muscular responses, such neutralizers should not be used around dangerous machinery, and if the shocks are extremely intense the neutralizer should not be used at all. However, those units that give only slight shocks can be used in open locations where there is no danger of injury to the operator.

Other safety tests should be conducted to determine the shock hazards derived from the high voltage cable connecting the neutralizer and transformer. If sparks and shocks from the insulated cable are of hazardous intensity, the cable should be enclosed in grounded conduits, rigid or armored, and supplied with Code fittings. Where flammable vapors are present, explosion-proof installations are recommended.

The threshold alternating current for lethal electric shock is about 70 to 100 milliamperes. Thus, neutralizer transformers must be specially designed to limit the short-circuit and sparking currents to, at most, 1/10 of this value. This is done by incorporating high reactance in a standard transformer to give it a low constant-current characteristic. Special transformers are available for this purpose.

Safety recommendations for install-

ing radioactive neutralizers are prescribed by the manufacturers of this equipment and enforced by local public health agencies.

Since the tufts of bristles in induction neutralizers are all grounded, touching the bristles causes neither shock nor sparks. For this reason, these units are inherently safe neutralizers. The festoon dryer, Fig. 7, with tension rolls operating in a flammable atmosphere, is fully equipped with tufted-type induction neutralizers. The wire bristles resist sparking since if the electrified stock inadvertently approaches the ionizing points, they ionize excessively, intensifying the discharge phenomena and nullifying the tendency to spark. In addition, the low electrostatic capacitance with respect to the electrified stock of tufted-type induction neutralizers reduces the energy below the ignition level in whatever small spark might occur.

The spreader, Fig. 8, is used for the coating of rubber and plastic compounds onto textiles, paper, and leather. The flammable vapors given off from the solvents in the coating compounds, shown by the dotted areas, commonly cause fires and explosions from electrostatic sparks. The unit is fully equipped for safe operation with tufted-type induction neutralizers.

How to Locate Neutralizers

Each location where static electricity is generated on a processing machine can be determined with an electrostatic voltmeter, indicating the magnitude of the voltage and its probable hazard potential. Before purchasing a full complement of neutralizers from one source, trial units should be obtained from various manufacturers for testing as to efficiency of operation and safety. This is especially true of high voltage units which should be tested for safe operation in accordance with the described procedure.

The following technique can usually be used to determine the most effective location for each neutralizer. A neutralizer with temporary adjustable mounting supports is secured to the processing machine at a trial position which should be about 3 to 5 in. after the break-away of the moving stock from the processing rolls, and about an inch above or below the electrified stock. To prevent the diversion of the electrified field, no unit should be located closer than 6 inches to any grounded cross member.

By using a probe attached to the free end of a well-insulated cable from the high voltage terminal of the electrostatic voltmeter, Fig. 1, the residual voltage distribution can be determined. The probe, consisting of a small tuft of sharp wire bristles, is held close to the stock, but not touching it, a few inches from the energized neutralizer.

By moving the neutralizer relative to the stock and the break-away point, the position can be located for which the probe voltage is least. The neutralizer should be permanently secured in this position. This same procedure can be followed until the machine is equipped with a full complement of neutralizers.

The probe voltage after each neutralizer should be practically zero or, at most, only a few hundred volts. If the voltage is in the order of several thousand volts, then only partial neutralization is being attained and other types of neutralizers that are capable of greater ionization should be tried.

Using this procedure on a pilot unit of each type of processing machine will determine the proper type and position of the required neutralizers. Future machines, identical to the pilot unit, can thereafter be equipped with neutralizers without further experimentation and testing.

FACTS TO REMEMBER ABOUT NEUTRALIZERS

1. Electrostatic neutralizers perform one or both of two functions. They remove fire, explosion and injury hazards that might result from electrostatic sparks; and they reduce spoilage of stock and products, and improve processing standards by counteracting the electromechanical effects of static electricity.

2. High voltage neutralizers that spark and cause shocks to operating personnel are unsafe.

3. High voltage neutralizers that spark when the stock being processed touches the ionizing points or when coating compounds, ink or other flammable products are thrown against the points can cause fires or explosions and should not be used in these applications.

4. In any processing area, and especially small enclosures, that is rendered hazardous by the presence of flammable mixtures, the use of high voltage neutralizers that may spark at their points is dangerous.

5. High voltage cable from the transformer to each neutralizer should be enclosed in a grounded conductive sheath or conduit. If this procedure is followed, there is no possibility of shocking personnel or of causing the ignition of ambient flammable mixtures through the electrical leakage of faulty or deteriorated insulation.

6. Radioactive neutralizers, either of the radium or polonium types, are smaller in cross section than the high voltage units and do not require a high voltage supply; however, they have the disadvantages of a low ionizing potency and of possible ill effects on the human system after long and direct exposure. Because of the latter effect, their use generally requires approval by the local health department.

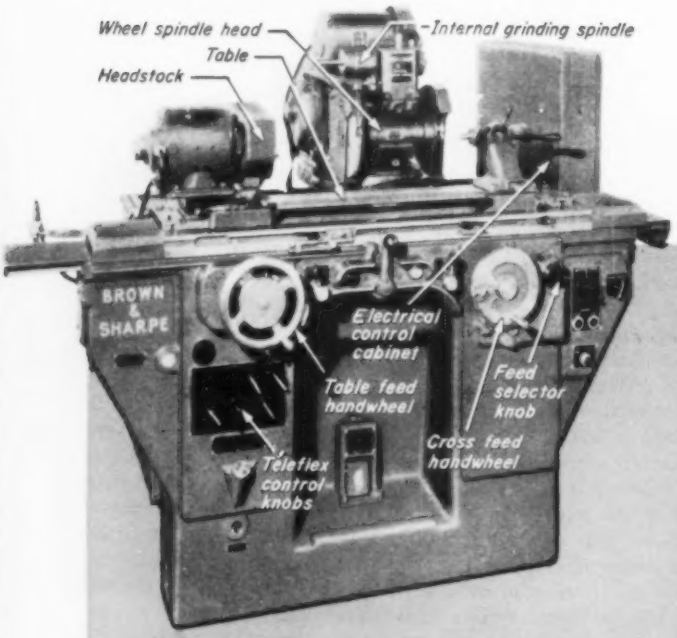
7. All high voltage and radioactive neutralizers are only capable of limited neutralization, above which no additional discharge of electrified stock can occur. Thus, highly electrified stock being processed at high speeds may become only partially discharged and may still retain potential sparking hazards.

8. With induction neutralizers, the ionization potential is unlimited and varies with the electrification of the stock. Thus, if ionization starts at a safe low voltage these units are well suited to applications of neutralizing any stock regardless of how intense the electrification or how high the processing speed.

9. Those types of induction neutralizers using tightly packed continuous assemblies of wire bristles secured in grounded metal backs, require a high value of induced potential to initiate ionization and do not reduce the potential of the electrified stock to a safe minimum value.

10. Induction neutralizers with the grounded bristles arranged in small tufts and properly spaced along a wooden bar start ionizing at a low potential and reduce stock electrification to a safe value. The cost of this type is low compared to that of high voltage or radioactive neutralizers and the tufted induction units perform more efficiently in many applications.

DESIGN FEATURES

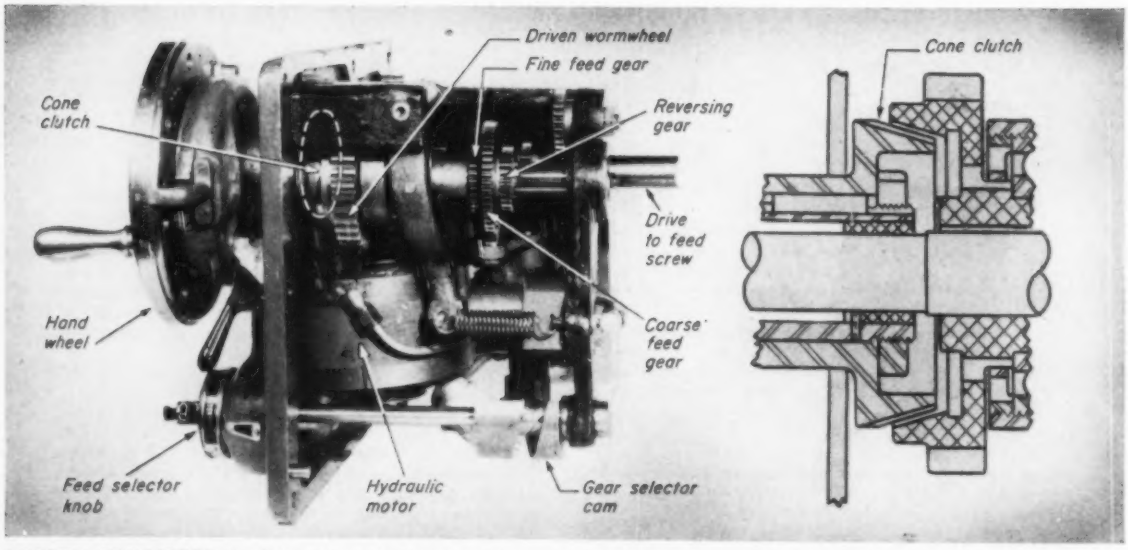


NEW UNIVERSAL GRINDING MACHINE employs hydraulic drives for both the table and wheel spindle head cross feeds, the rates of which are adjusted through Teleflex controlled rotary valves on the central hydraulic-control panel, not shown.

Hydraulic Motor

A precision vane-type hydraulic motor that can operate efficiently at speeds as low as 2 rpm for in-feeding and up to more than 1500 rpm for rapid retraction of the wheel spindle head enables the Brown & Sharpe Mfg. Co., Providence, R. I. to incorporate into their new series of Universal Grinding Machines an extremely fine power cross feed, adjustable down to 0.00005 in. which produces 0.0001 in. sizing on the work diameter.

Contained within the cross feed housing, the hydraulic motor drives the cross feed screw through a sensitive cone clutch in a simple gear train. Gears are used to obtain both a coarse and a fine handwheel movement of the wheel slide, and to reverse the feed screw without



POWER CROSSFEED is driven by a hydraulic motor, a worm on the motor engaging a worm wheel on the handwheel shaft. A sensitive cone clutch, shifted hydraulically, transmits the drive to the feed screw through the feed selection gears. The feed selector knob, when turned, rotates a cam positioning the gears for coarse, fine or reverse handwheel movement of the cross slide. Section shows the cone clutch. Axial movement is only $\frac{1}{64}$ in.

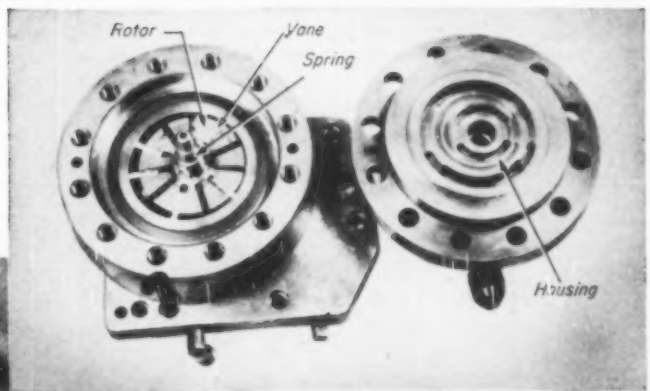
Increases Grinder's Sizing Accuracy

changing the direction of handwheel rotation. This reversing feature enables the operator to employ the handwheel positive stop with the same 0.0001 in. sizing adjustment for both external and internal grinding.

All the hydraulic control valves including those for regulating the fine and coarse feed rates, table dwell and continuous in-feed selection, are mounted on a hydraulic distribution panel in the left side of the machine. Composed of two plates with channels between them to supply oil to the individually mounted control valves, the hydraulic panel design permits the removal of any component without disconnecting any piping or hydraulic couplings.

Teleflex units, marking their first appearance in the United States on a standard machine tool, permit the control knobs to be located at the front of the machines in convenient operating positions yet place the valves together on a single panel immediately accessible at the side of the machine.

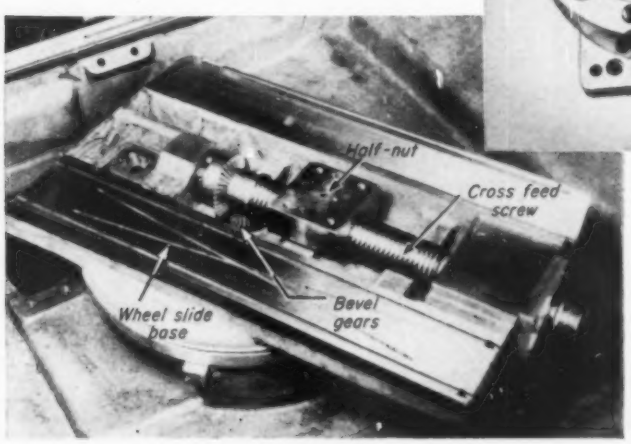
To permit the setting of the grinding wheel spindle at any angle in the horizontal plane, the wheel spindle head can be rotated on two swiveling members, both graduated to indicate angular positions. The lower swivel gives cross feed motion at any angle from 0 to 90 deg with reference to the table travel. The upper swivel is mounted on an eccentric plate which is rotated independently of the other two angular positions for the purpose of adjusting the spindle head either parallel or at right angles to the cross slide ways to give increased flexibility and range.



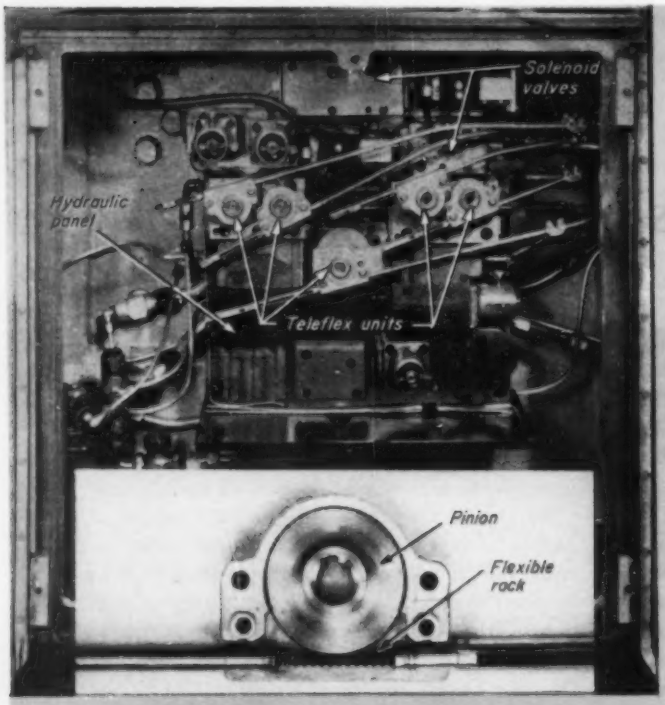
VANE-TYPE HYDRAULIC MOTOR rotates down to 2 rpm for extremely fine infeeding, and when reversed, speeds up to 1500 rpm for rapid retraction of the cross slide. Speed of the motor is varied by a throttled flow of oil. Measured volumes of oil are metered into the motor for intermittent feeding operation.

(*continued on next page*)

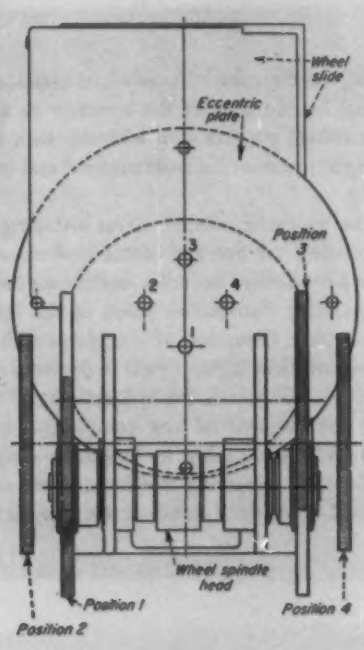
WHEEL SLIDE BASE shows the large cross-feed screw driven by bevel gears from the hydraulic motor. Uniform tracking of the wheel slide is maintained by broad Vee and flat ways of the base.



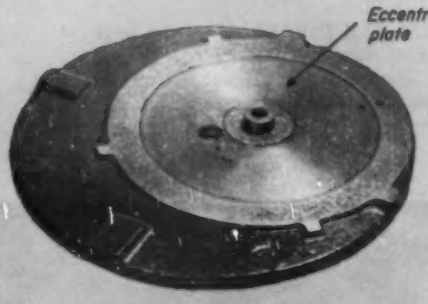
Grinding Machine (continued)

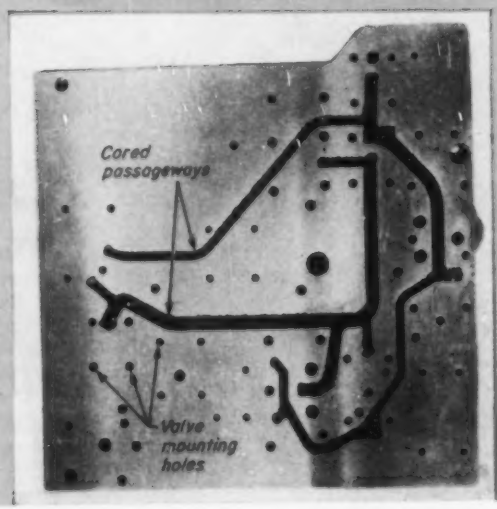


HYDRAULIC COMPARTMENT features centralized mounting of control valves for maintenance ease and accessibility. Teleflex units are mounted on the shafts of rotary control valves and permit remote control by the operator. Insert shows cover removed from a Teleflex control.

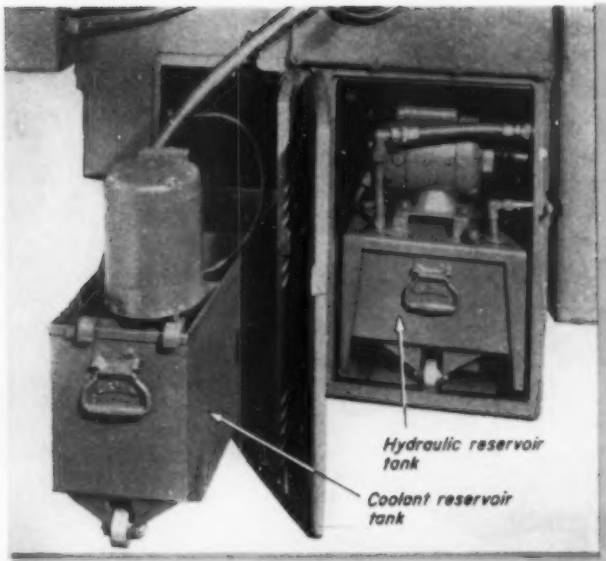


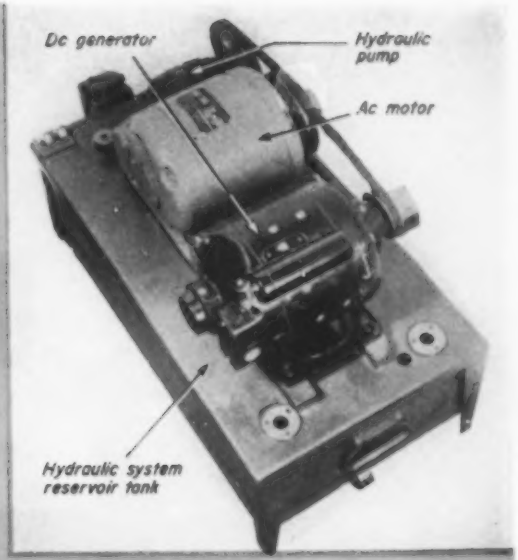
ECCENTRIC PLATE, or Universal Turret, is used to position the wheel spindle head relative to the wheel slide to increase flexibility and capacity of the machine. Positions 2, 3, & 4 shown in the plan view of the spindle head locate the grinding spindles further to the rear of position 1; and, in addition, intermediate positions, place spindles to the right or left of position 1.



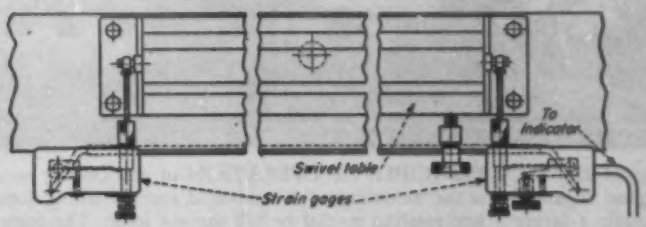


HYDRAULIC PANEL consists of two plates, one cored on the face with passageways to interconnect the control valves. Design permits valves to be front mounted on the panel, eliminating piping between valves.



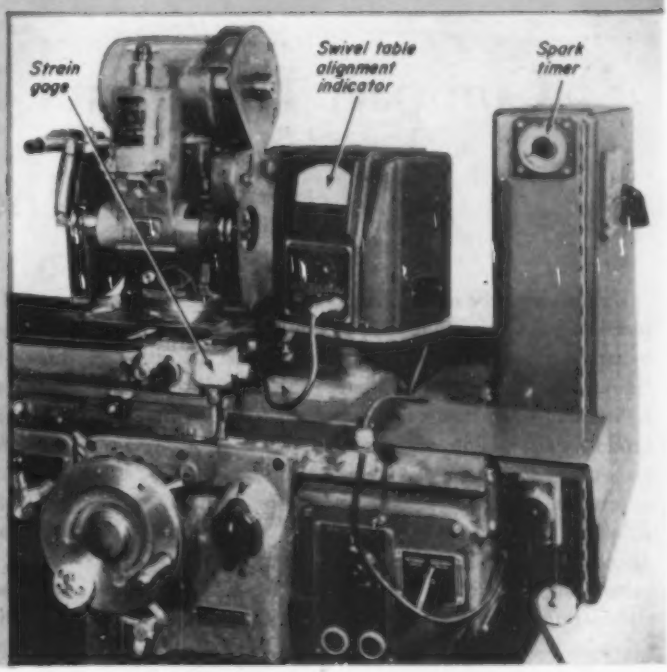


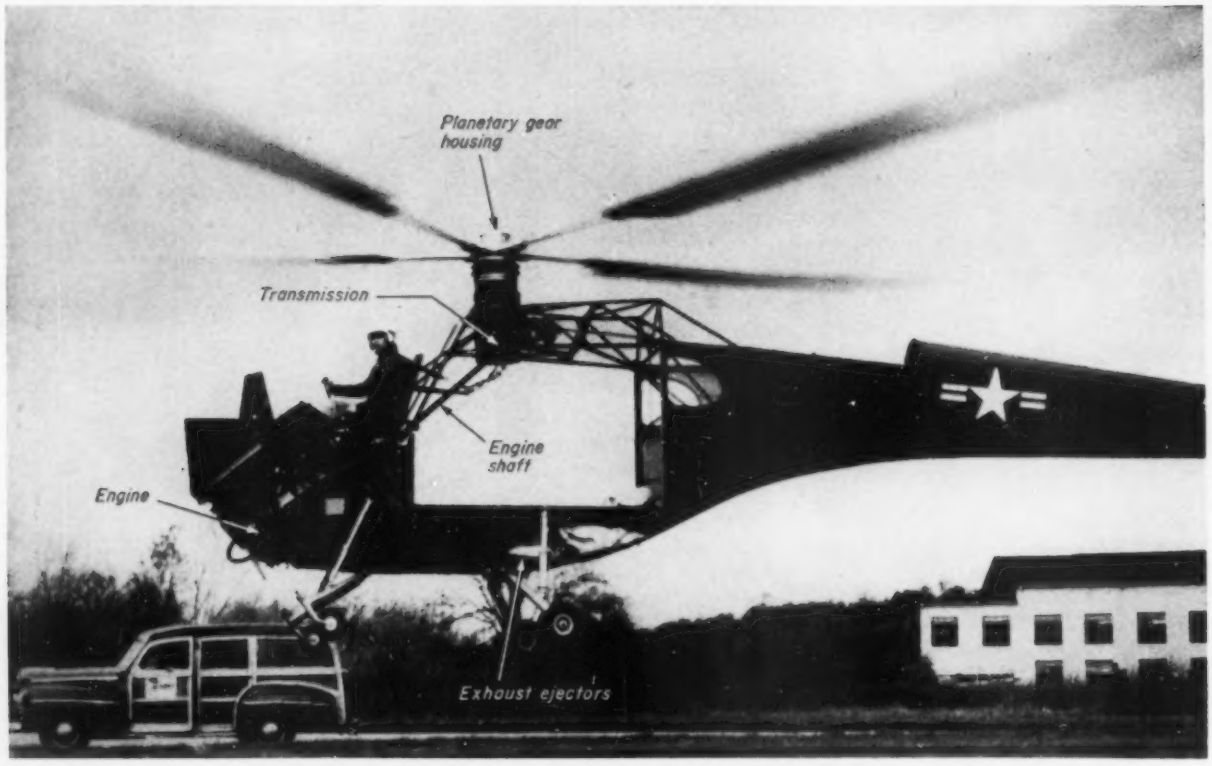
HYDRAULIC and coolant system reservoirs are contained in removable, wheel-mounted steel tanks. Mounted on the hydraulic tank are an A.C. motor with V-belt drives to the hydraulic pump and the D.C. generator for the headstock motor. Removable tank design features accessibility and ease of maintenance.



SWIVEL TABLE aligning device consists of two strain gages set one at each end of the swivel table and connected to a direct reading scale. This unit is used to accurately control the relation of the swivel table with the sliding table, and to maintain the angular position of the work axis with respect to the grinding spindles.

ACCESSORIES that can be added to the standard machine to improve overall grinding efficiency and uniformity include the automatic cycle and spark timer, and the built-in strain gage arrangement for checking the alignment of the swivel table. The spark timer is used to preset the time allowed for the grinding wheels to contact the work with the feed disengaged before stopping the complete operation.





HELICOPTER, shown without doors and super-structure, is powered by a 400 hp reciprocating engine mounted under the cab area. Simplicity of design permits a larger open area for cargo loading. The doors measuring seven feet in width facilitate handling of bulky loads.

PRINCIPLE OF OPERATION of the Doman rotor head is the mounting of a semi-rigid type of tilting rotor on a non-rotating gimbal or ball support joint. The rotor hub is driven through a constant angular speed joint located at the tilt center, preventing rise of Coriolis forces.

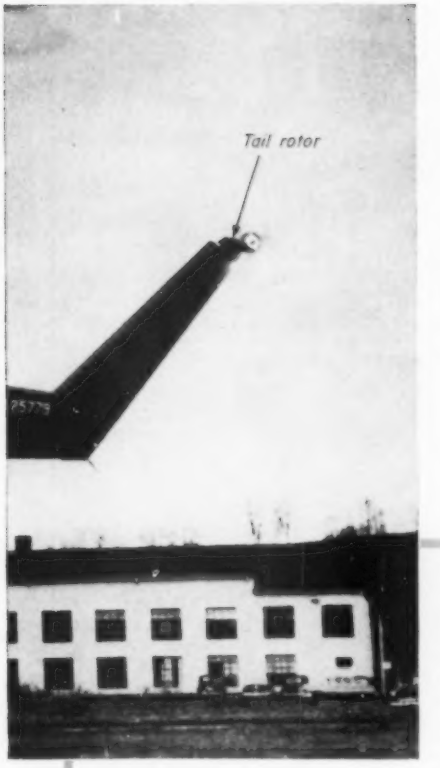
Compact Helicopter Design Lowers Weight and Increases Payload

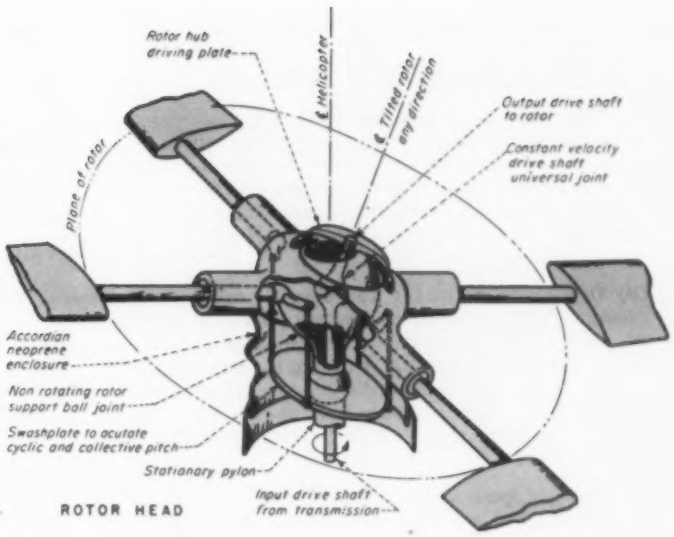
By designing the rotor head and transmission for compactness and a minimum number of operating parts, and by using tubular frame construction almost exclusively throughout the structure—both features allowing a lighter engine to be used—Doman Helicopters, Inc. has produced a new ship with a useful load to gross weight ratio of 43 per cent.

A unique fluid coupling is used to give a smooth transition of engine torque to the rotor, and to supply a direct drive for flight operation. The clutch operates to permit engine turning without churning of oil, thereby eliminating the need for any cooling. Also, the special drive features of the clutch enable a much smaller unit to be used than is generally required for a 400 hp engine.

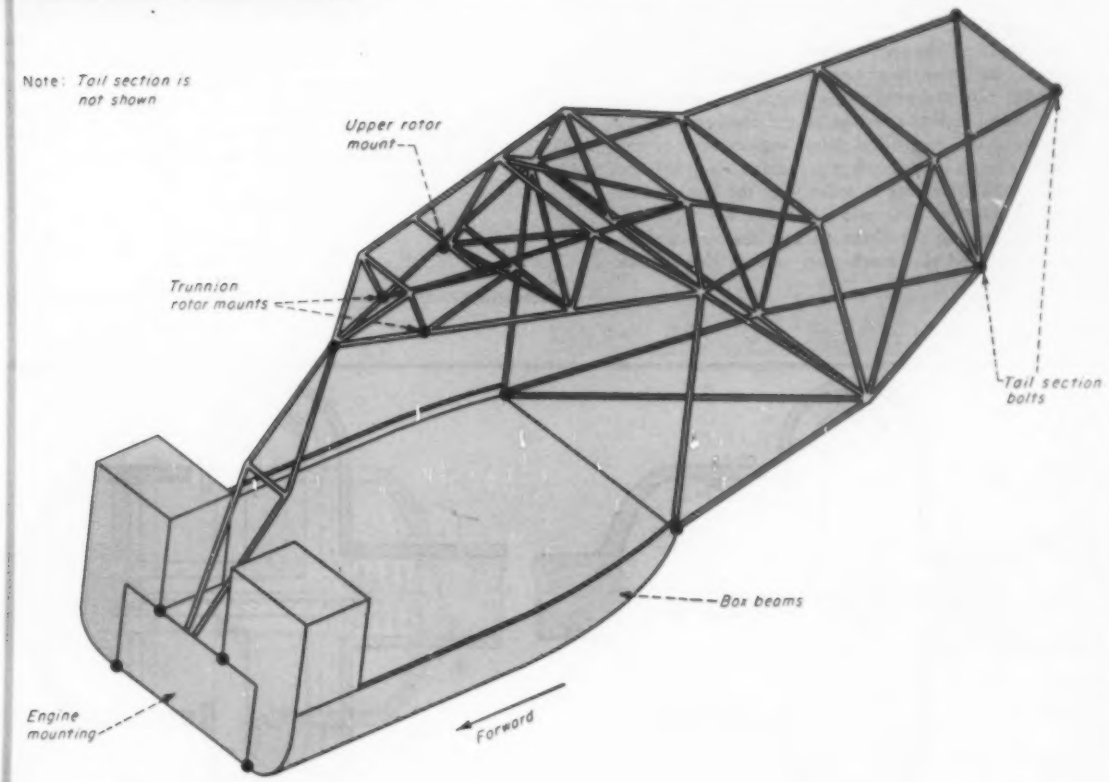
Engine cooling is done without the use of separately driven blowers, or other moving parts. Exhaust ejectors mounted on each side of the engine housing draw cooling air into the housing during all operating conditions, and affect a substantial horsepower saving over conventional cooling systems.

Welded tube construction enables the fuselage to be built cheaper and faster than conventional stressed skin design. A major element of the structural design is the overhead support for the rotor head and transmission, the entire assembly being supported on two diametrically opposed trunions.




Rotor hub driving plate
℄ Helicopter
℄ Tilted rotor any direction
Output drive shaft to rotor
Constant velocity drive shaft universal joint
Plane of rotor
Accordian neoprene enclosure
Non rotating rotor support ball joint
Swashplate to acutate cyclic and collective pitch
Stationary pylon
Input drive shaft from transmission
ROTOR HEAD

WELDED SMALL DIAMETER TUBING, built into sections and bolted together for ease in dismantling and repair, is used almost exclusively in the construction. Only exceptions to the use of tubing are the box beams making up the floor, fuel tank and engine housing sections. Tubing design reduces construction and assembly costs, and does not require the use of fuselage paneling for structural strength.



Helicopter (continued)

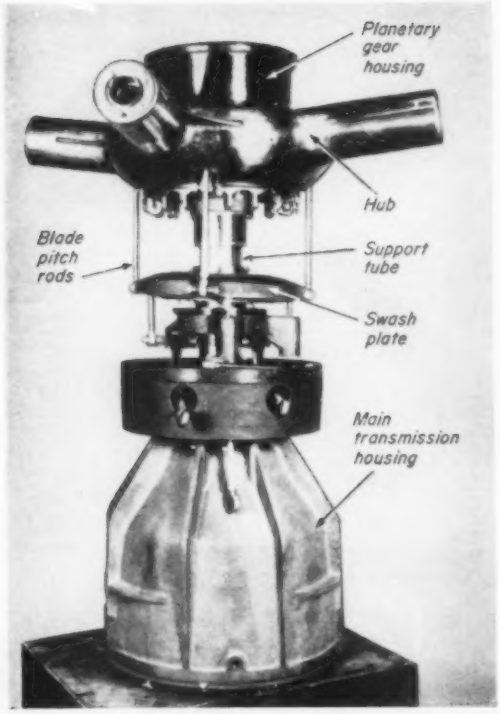
FLUID COUPLING: HOW IT WORKS

(A) When idling, the engine operates without transmitting any drive to the rotor. Engine oil pressure acting upon a piston prevents a control rod from contacting a set of brake shoes. Only driven member is the fluid coupling housing, the bucket wheel and attached brake shoes rotating without carrying any torque load or churning of oil.

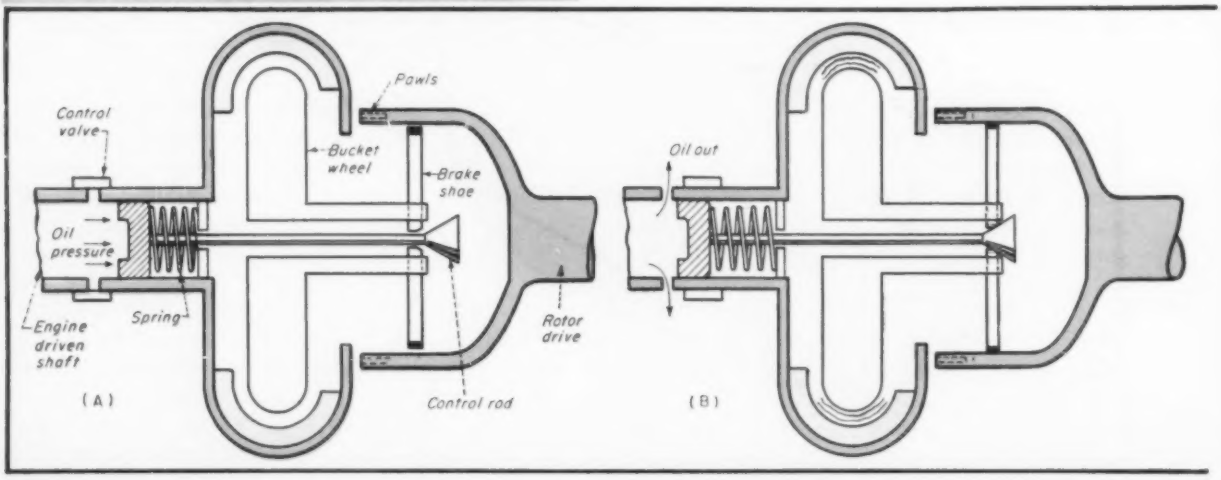
(B) To minimize the starting load when first transmitting the engine drive to the rotor, oil pressure is released behind the piston, allowing the spring loaded control rod to move to the left. A cone on the end of the control rod contacts the brake shoes and forces them out against the rotor drive housing. The housing begins to rotate, the drive being transmitted through the clutch fluid.

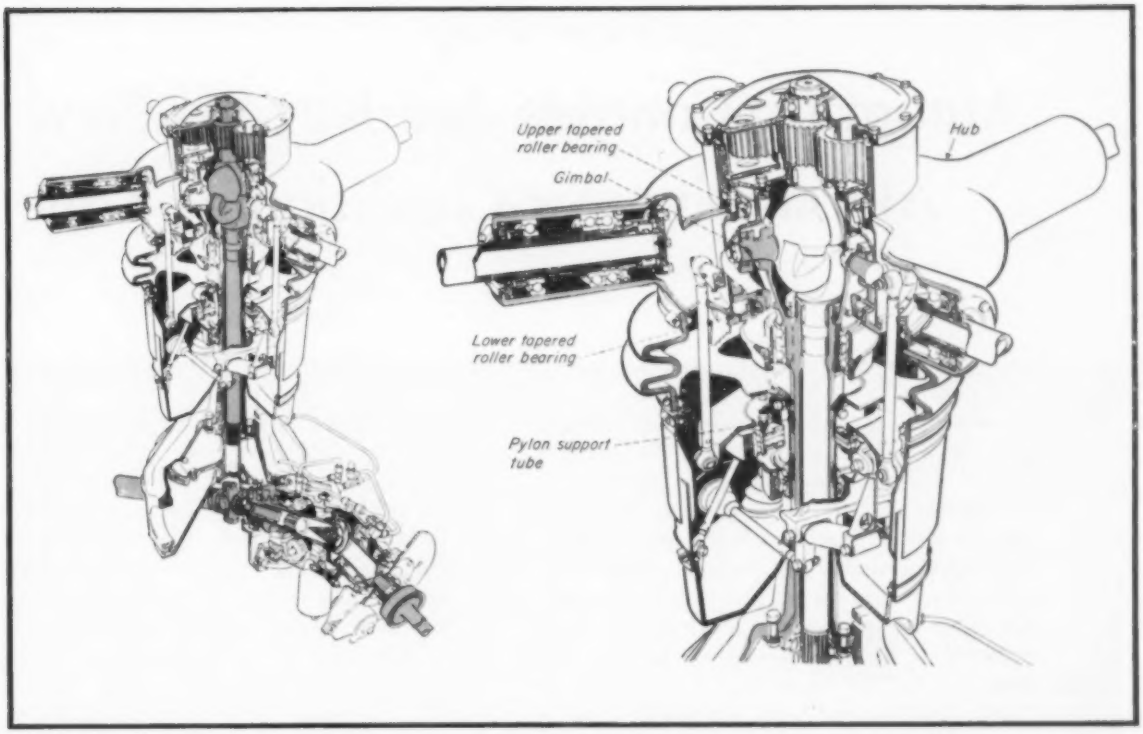
(C) For flight operation requiring full engine power, the rotor is driven by a direct mechanical drive from the engine. An increase in engine speed causes a number of spring loaded pawls to move out by centrifugal force and mechanically connect the fluid coupling and rotor drive housings. Actual engaging of the pawls is accomplished by momentarily slowing the engine permitting the pawls to fall into indexed notches in rings directly driven by the coupling housing. The bucket wheel rotates freely without oil churning.

(D) Pawl engaging device consists of a drive ring bolted to the drive clutch housing, a blocker ring in friction contact with the drive ring and a pawl carrier keyed to the output shaft. At increased engine speed, the drive ring rotates faster than both the blocker ring and pawl carrier, with the pawl forced against an indent shoulder of the blocker ring. To complete the mechanical drive, engine speed is momentarily checked slowing the drive ring. Friction causes the drive ring to index with the blocker ring letting the pawl drop into a notch on the drive ring and completing the direct drive to the output shaft. Six pawls and nine notches are used to give a quick coupling action.



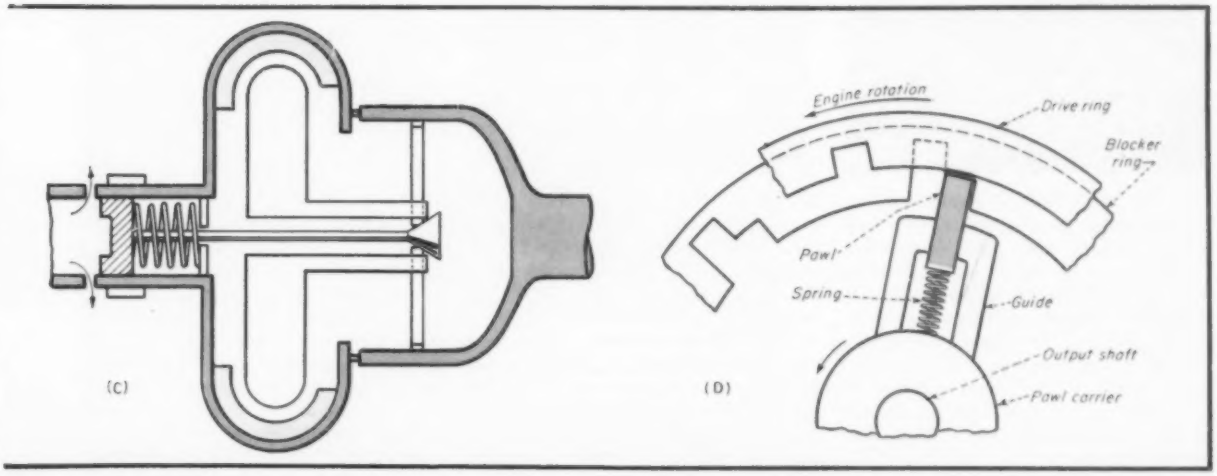
MAIN TRANSMISSION and hub feature compactness and accessibility to major components. Entire assembly is bathed in oil, the oil being forced between the support tube and rotating shaft up to the planetary gears and then falling down over the other moving parts. A flexible neoprene enclosure, not shown, prevents the oil from being thrown out and allows a quick access for inspection of controls. Entire assembly is supported on only two trunnions.





DRIVE from the engine to the rotor is transmitted through a universal joint and free-wheeling clutch to a pinion engaging a spiral bevel reduction gear connected to the rotor drive shaft. Rotating within a stationary support tube, the shaft drives through a constant velocity universal joint to the sun gear in the upper planetary gear box. The planet carrier then drives the rotor hub. Tail rotor drive is from the spiral bevel pinion gear, the drive being transmitted through a pair of engaging mitre gears.

THRUST LOAD from the rotor hub passes through the lower tapered roller bearing to the non-rotating gimbal, and from the inner ring of the gimbal to the support tube. This design prevents any axial loads being transmitted to the rotor drive shaft or constant velocity joint. Also, by mounting a teetering rotor without hinges to a non-rotating gimbal, and using a constant angular speed joint at the center, Coriolis forces are eliminated. And rotor stresses are not affected by the location of the c.g.

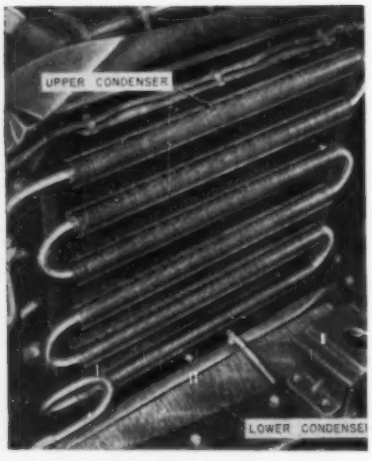


Automatic Controls Are Key To New Automotive Air-Conditioning Unit

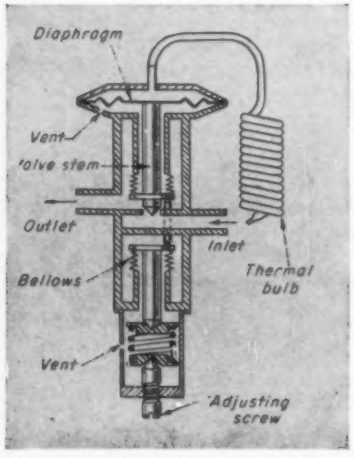
Main difference of Chrysler's car air-conditioner from a conventional system is the use of additional automatic controls to compensate for variations in motor-driven compressor speed, and to offset the tendency of the system to cool too rapidly under fast driving conditions. Another controlled feature —necessary during winter driving—is the positive flow of hot refrigerant gas to insure the return of entrained oil in the Freon system back to the compressor for lubrication.

Components of the system, differing only from the usual elements in layout, are the compressor, split condenser, receiver, dryer, expansion valve and evaporator. Two electric driven centrifugal blowers powered by a single motor take air from the car interior and blow it across the evaporator coil back into the car. To maintain a fresh supply of air, inlet ports located on each side of the car at the rear are also connected to the blower intakes.

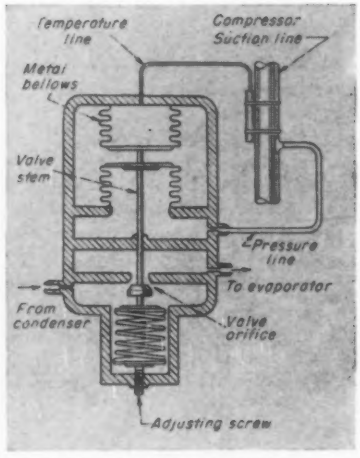
The compressor, belt driven from the engine, reaches design cooling load at 25 mph. For normal driving conditions, the hot gas is discharged



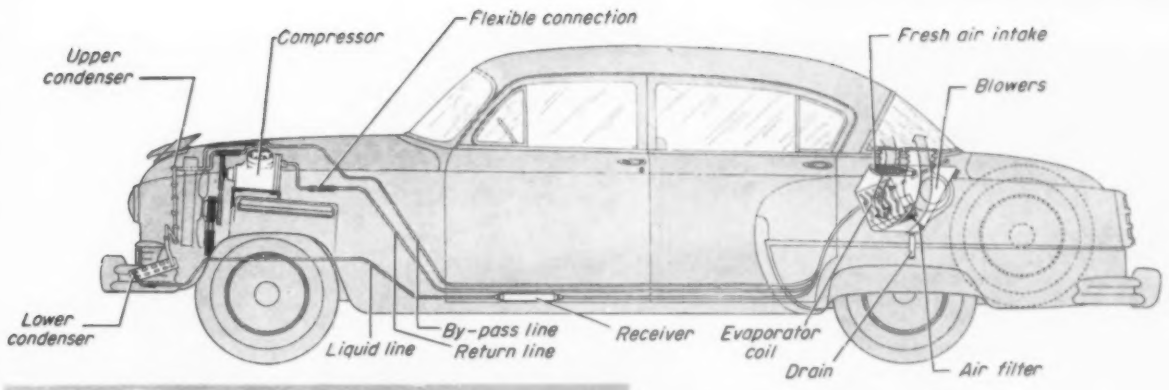
SPLIT CONDENSER consists of an upper section constructed of six loops of steel tubing with spiral fins, and a lower unit made up of aluminum fins on copper tubing. Split design is used to insure adequate cooling air passage to the engine, the lower condenser doing approximately two-thirds of the total heat transfer. Lower section has no effect on engine cooling as air flows under radiator for discharge beneath the car.



AUTOMATIC BY-PASS VALVE gives additional control over minimum car interior temperatures and automatically regulates the system when the blowers are shut off. When the temperature falls, vapor in the thermal bulb contracts and lowers the pressure on a diaphragm to allow a spring loaded valve to open releasing hot gas to the evaporator coil. Bellows seal off the valve stem and spring to prevent changes in valve's position.

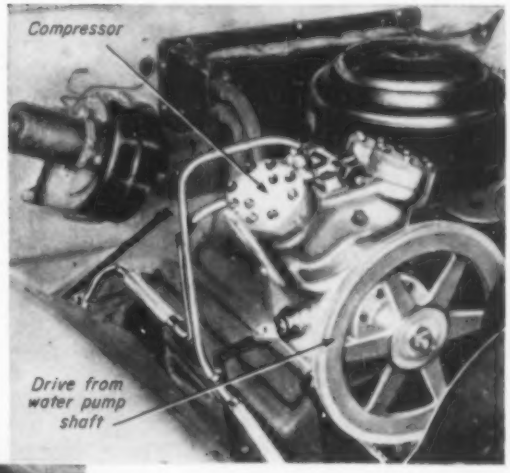


THE EXPANSION VALVE is essentially a variable orifice whose size is controlled by the temperature and pressure of the refrigerant leaving the evaporator coil. A temperature rise in the suction line causes the metal bellows to expand opening the valve to allow greater flow for full evaporator capacity. Also, the valve prevents liquid refrigerant from entering the compressor suction line where its presence would cause damage to the compressor.

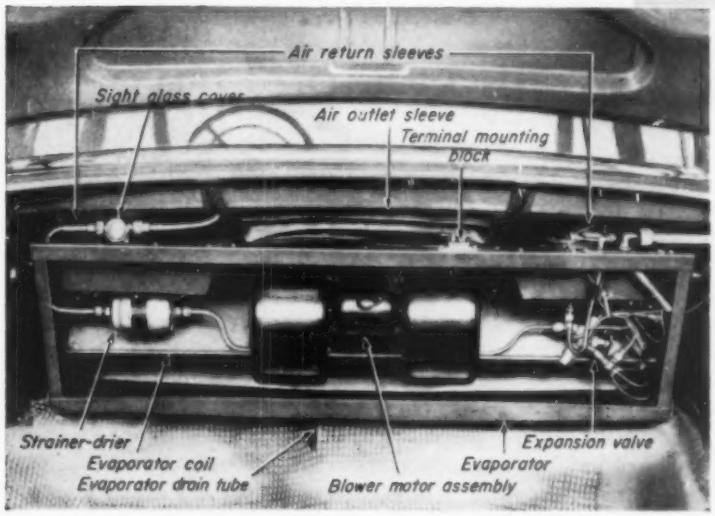


to a split condenser ahead of the car radiator, to a liquid receiver, and through an expansion valve into the evaporator coils. After absorbing heat from the cooling air, the refrigerant flows back to the compressor. For low cooling loads, the hot gas is by-passed from the compressor directly to the evaporator, controlling the coil temperature. And with the blowers turned off, as during winter driving conditions, an aluminum strip conducts heat away from the thermal sensing bulb to the cold evaporator actuating the control valve.

COMPONENTS of the air conditioning system are mounted in seldom-used locations without any significant loss of useable space. Basic element in the unit is the engine-driven compressor which supplies up to 1¼ tons of refrigeration at a car speed of 25 mph for rapid cool down.

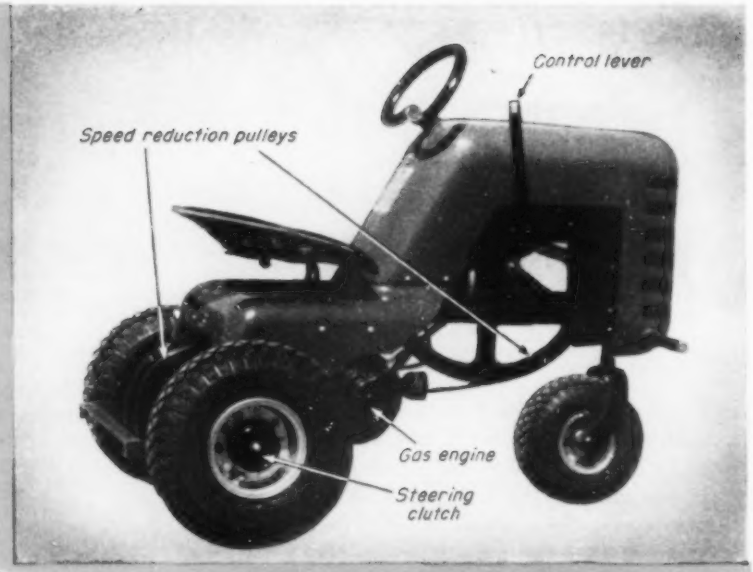


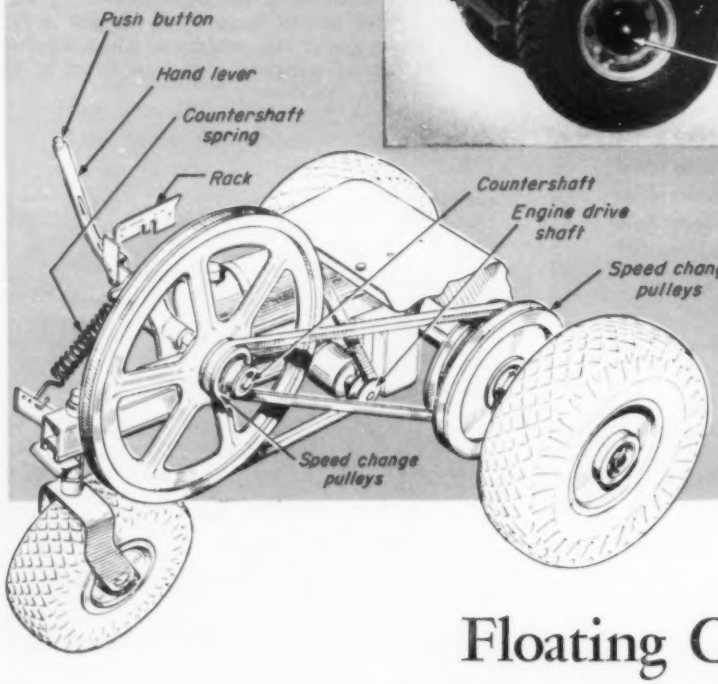
(RIGHT) Installed on the right side of the engine, the 73 lb compressor is secured by brackets attached to the intake and exhaust manifolds and water pump casting. The four-cylinder, V-type piston unit is belt driven from the water pump shaft, and is designed to operate at low crankshaft relative speeds.



EVAPORATOR ASSEMBLY is secured to the double floor between the wheel housings and the rear seat shelf. Flexible rubber ducts carry cooled air, the maximum flow of which is 400 cfm at a blower speed of 1750 rpm, to the car interior where it is directed up and along the roof toward the front.

TRACTOR is designed for use with various accessories such as mower, sweeper, roller, seeder, etc, the units being fitted with a simple toggle bolt arrangement for quick engagement and release from the tractor. Tires are inflated to 10 lbs for operator comfort and to prevent impressions on the ground.





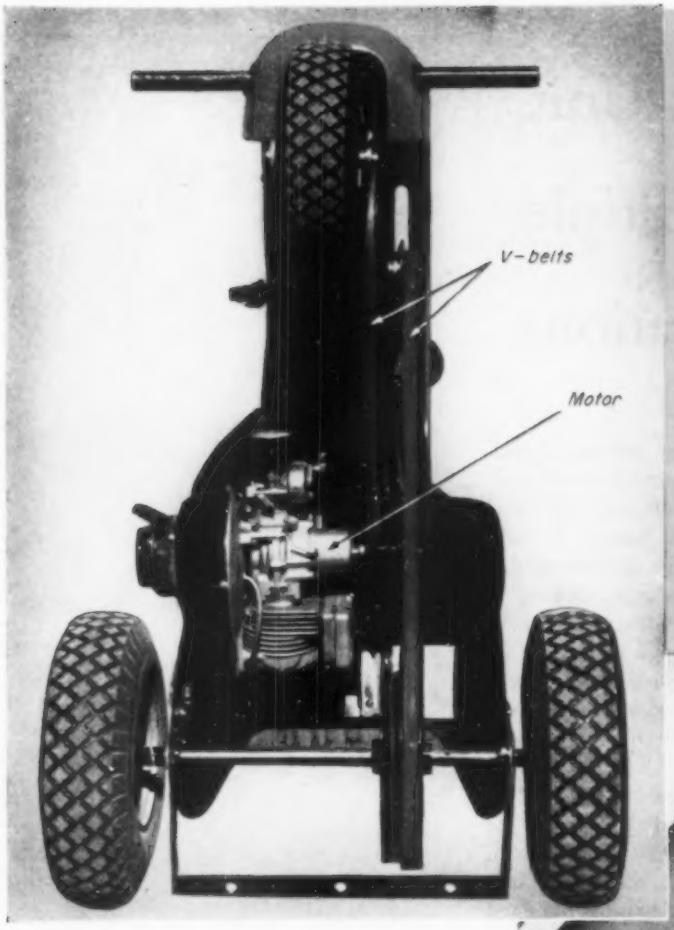
SPEED REDUCTION is obtained in two stages: from the engine pulley to the countershaft pulley, and from the output units on the countershaft to the pulley keyed to the rear axle. Belt changes are made manually with the hand lever in the belt change position. At high speed, engine speed is reduced 25 to 1, for low speed—42 to 1.

Floating Countershaft Controls Garden Tractor Drive

By using a hand lever to pivot a countershaft assembly for three operating conditions by increasing, decreasing or releasing the V-belt drive from the engine, the Hiller Engineering Company, Redwood City, California was able to build into their new, mechanical garden-tractor a two-speed transmission, an "inertia" brake and a quick belt change position.

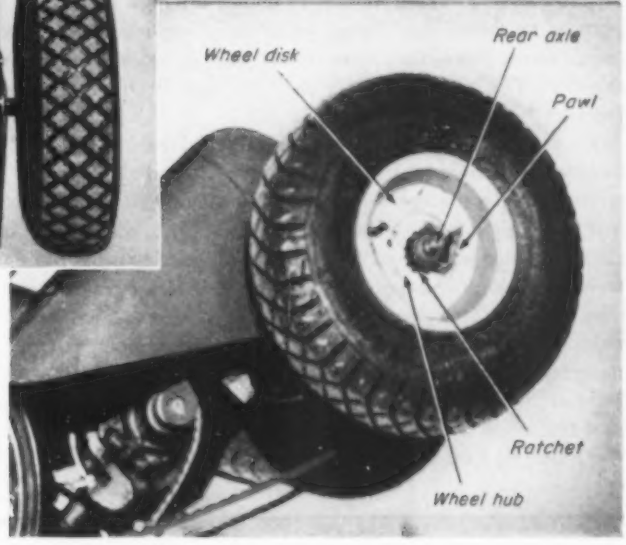
Weighing only 145 lbs and measuring but 44 in long, 27 in wide and 32 in high, the "Yard Hand" is capable of a 200 lb static drawbar pull. Powered by a 1½ hp air-cooled gasoline engine, the power being transmitted by cog belts through different sized pulleys to give a two-stage speed reduction, the new tractor is designed for 2 mph in low and 4 mph in high speed.

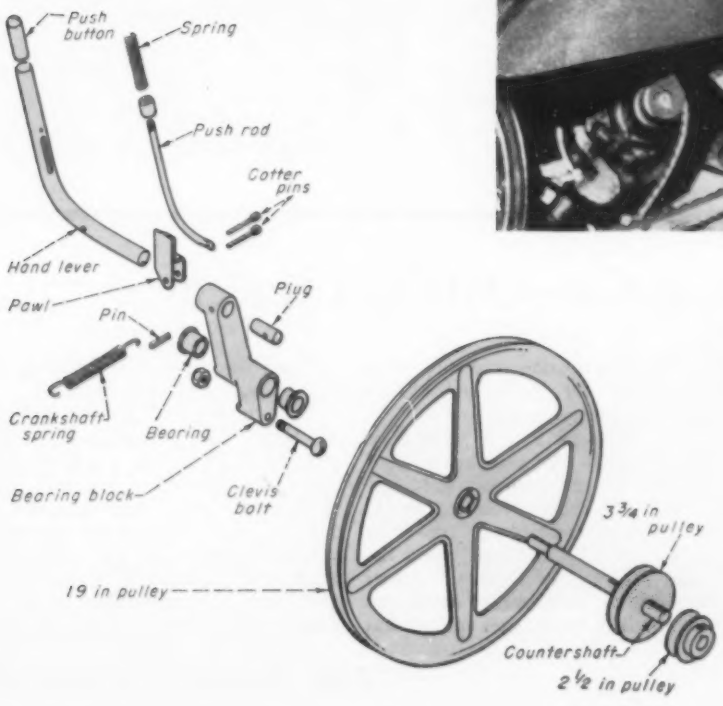
Special ratchet-type clutches, one at each end of the rear axle, enable the wheel drive to be easily disengaged for making sharp turns and increased maneuverability. Low-cost versatility is the keynote behind the miniature tractor's design. It is built as a highly mobile "power-package" for operation with a wide range of accessories. The tractor can be quickly converted, by virtue of its simple toggle bolt attaching device, from one gardening use to another, It can also be equipped with a hood mounted 10 in. circular power saw as a mobile tool.



(LEFT) The 2 cycle gasoline engine is suspended from the tractor yoke, under the seat, by four rubber shock absorbers. An automatic rewind on the engine starter simplifies the starting operation. A mechanical flyball governor keeps the engine speed set at 3400 rpm, the peak of the power curve for the engine.

(BELOW) Adjustable steering clutches are used to give a sharp turning radius. Rotating the hub cap disengages the pawl from the ratchet keyed to the rear axle, permitting free wheeling. To engage the drive, the hub cap is turned back to its original position engaging the hub mounted pawl with the ratchet.





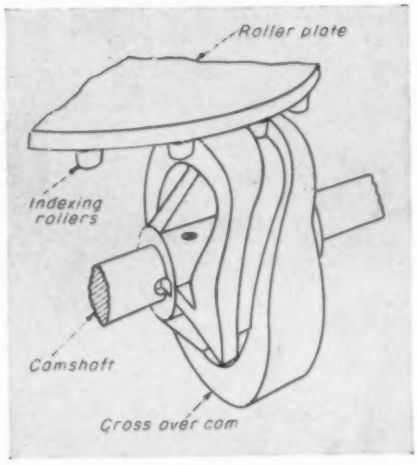
TO ENGAGE or disengage the power from the engine, or to move the countershaft pulleys closer to the engine and rear axle pulleys for belt change, movement of the hand lever pivots the bearing block about a clevis bolt or fulcrum. This action moves the entire countershaft assembly, if forward to increase belt tension for added traction or back, to release belt tension for stopping or belt change. A pushbutton on the hand lever disengages the spring loaded bearing block, allowing free movement of the assembly for pivoting.

Standard Turret Unit for Multiple Indexing Applications

By designing an index plate with a calculated number of radially mounted cam followers and then matching the follower spacing with a cross over cam to give desired indexing and dwell periods, a wide range in intermittent motion is obtained by varying the indexing rates and dwell times through interchangeable gears transmitting the drive from high and low speed motors.

Developed by Swanson Tool and Machine Products, Inc., Erie, Pa., as a basic indexing motion to reduce the high cost of special purpose machines, this design principle is applied to a self-contained turret chassis for applications requiring indexing rates ranging from 176 to 4700 indexes per hour and dwell times varying from 15.3 down to 0.5 seconds.

To extend the range of the unit, a radial base is designed to follow the contour of the turret periphery. A radial keyway in the section permits the mounting of additional operating elements in accurate register with turret work positions. Also, the turret is constructed with a stationary center plate for mounting other tools and to furnish necessary support for heavier tools secured to the extension brackets. To accommodate larger machine tools not practical to mount on the radial plates, a series of standard floor base plates, designed as steel weldments, allow positioning of the entire indexing unit to suit particular applications. And the use of tapered cam followers and matching cam paths prevent any play during the indexing motion and work periods.

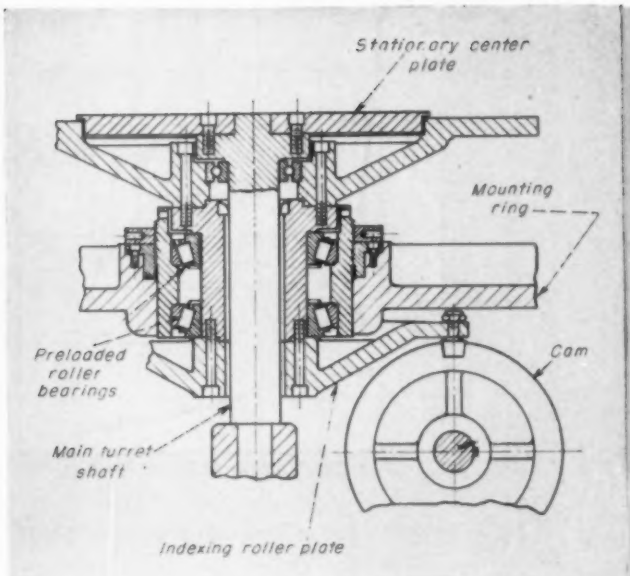


New Russian Car—Old Opel Kadett

WHILE REPRESENTING a number of basic improvements over its predecessor model introduced in 1948, the new Moskovitch (MKV) car bears a more than striking appearance to the pre-war German Opel Kadett.

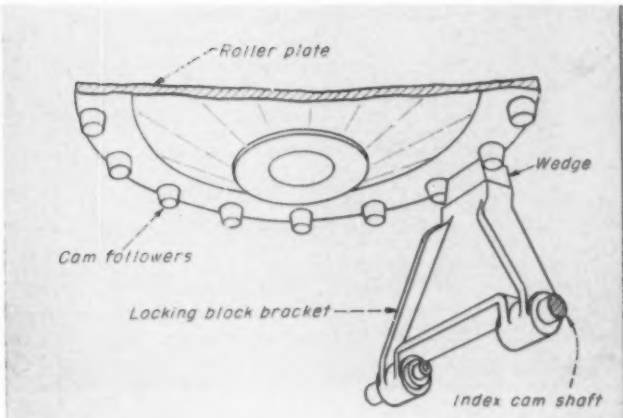
The instrument panel of the Moskovitch is identical to the 1939 car, both in the type and layout of accessories. The MKV's 4-cylinder engine has the same piston displacement, bore, stroke and compression ratio. And the transmission consisting of a single plate dry clutch and a four speed gear box having a ratio of 3.56 to 1 in low and 1 to 1 in high is quite similar to that used in the Opel Kadett. Other features seemingly adopted from the pre-war German car are the Dubonnet system for front wheel suspension and four wheel hydraulic brakes. The Dubonnet system consisting of independent suspension with specially housed coil springs was not only used on the Opel Kadett but also on early Chevrolet models.

Fuel consumption for the new 27 hp MKV (Opel Kadett had 23 hp) is rated at 35 mi per gal at cruising speeds between 45 to 50 mph. Top speed is 65 mph. The carburetor is Russian made, but closely resembles a Carter down draft unit. The electrical system, similar in appearance to the Bosch design, consists of a 6 v Dutch made battery rated at 75 amp-hr



(LEFT) Built as a "packaged unit" for intermittent motion applications, the wide range of indexing speeds and working cycles is obtained by using three different worm gear ratios, a 870 and a 1740 rpm motor, and variable pitch sheaves on the drive shafts. A radial base section located 2¾ in below the turret face is used to mount additional tools for increased versatility in operation.

(RIGHT) Cartridge type construction consisting of assembling the entire turret shaft and index plate as one unit permits complete and simple adjustment of the indexing roller plate relative to the cam. This packaged assembly also insures the ease of field adjustment for wear without the need to disassemble the machine except as components.



(LEFT) Uniform acceleration and deceleration is obtained in the 90 deg section or outer periphery of the cam. The remaining 270 deg comprise the turret idle or work period of the cam. The tapered contour of the rollers and cam path insure constant contact for smooth and accurate indexing.

(RIGHT) Positive locking of the index plate is obtained by moving a wedge shaped block between two adjoining cam followers. The block engages the rollers and completely relieves the contact between the cam and cam followers.

and a Russian made 300 w generator furnishing a 19 amp charging current.

Probably the biggest new feature on the car is an unique design for facilitating brake adjustment. The wheel hub caps need only be removed to get at the adjusting mechanism.

The new 4-door MKV sedan is shown at the right. Aimed at the small-car class European market, the car is 150 in. long, 55 in. wide and has an 85 in. wheelbase. One of the sales features is a spare parts kit containing such items as valves, valve seats, waterpump repair kit, ball bearings, swivel pins, and extra hub caps.

HIGH PURITY METALS

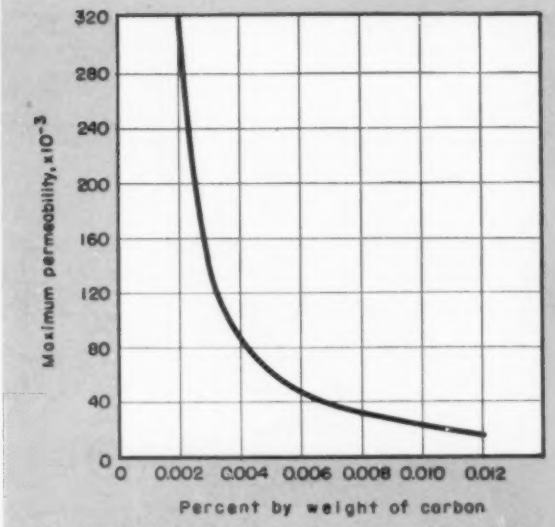


Fig. 1—Effect of carbon on maximum permeability of iron.

Metal processors are finding it necessary not only to continue the search for new metals and alloys, but also to critically re-evaluate older ones. One outgrowth of this battle between quality control and product is the realization that minor impurities often control, and occasionally obscure, the true properties of metals.

DANIEL J. MAYKUTH
Battelle Memorial Institute

Table I—Mechanical Properties of Four High-Purity Metals

Property	Aluminum	Iron	Titanium	Zirconium
Minimum Purity..	99.99	99.9	99.9	99.9
Yield Strength (0.2%), psi	2,800	15,900*	27,000	15,900
Ultimate Strength psi	7,200	34,800	43,000	35,900
Elongation, percent	50	53	40	31
Modulus of Elasticity	.....	.....	16x10⁶	11.4x10⁶

* Lower yield point

AN AXIOM of orthodox metallurgy is that a pure metal exhibits maximum electrical conductivity, magnetic permeability, corrosion resistance, and ductility, along with minimum yield and tensile strength. Because of this low strength characteristic, most high-purity metals are rarely selected for applications in which load-bearing capacity is the primary requirement. This reasoning is apparent in Table I which lists the mechanical properties of two established members and two newcomers among the structural metals.

Contaminating elements increase the strength of pure metals, but generally at the expense of other properties. Dissolved impurities tend to exert a more potent effect than those which show no solubility. In this respect, nonmetallic elements such as carbon, boron, oxygen and nitrogen are more difficult to eliminate and have a greater effect on properties than do dissolved metallic elements.

ZINC

The history of the "old" established metals demonstrates that, by improvements in quality, property changes can be achieved which lead to new uses for the metal. The growth of the zinc industry, for example, is directly attributable to successive improvements in the purity of this metal. The earliest market for zinc was in galvanizing operations, and only occasionally were higher quality lots (i.e., low in lead and arsenic) produced which could satisfactorily be used for making brass. Continued improvements in quality led to the establishment of the "four-9's" grade zinc, and then came the successful use of zinc in die cast alloys for a wide variety of parts.

ALUMINUM

A more recent example of new uses developed by improved properties through higher purity is the reflectivity of 99.99 percent aluminum. Data are shown in Table II along with similar values for other reflector-type metals.

Maximum reflectivity is obtained by

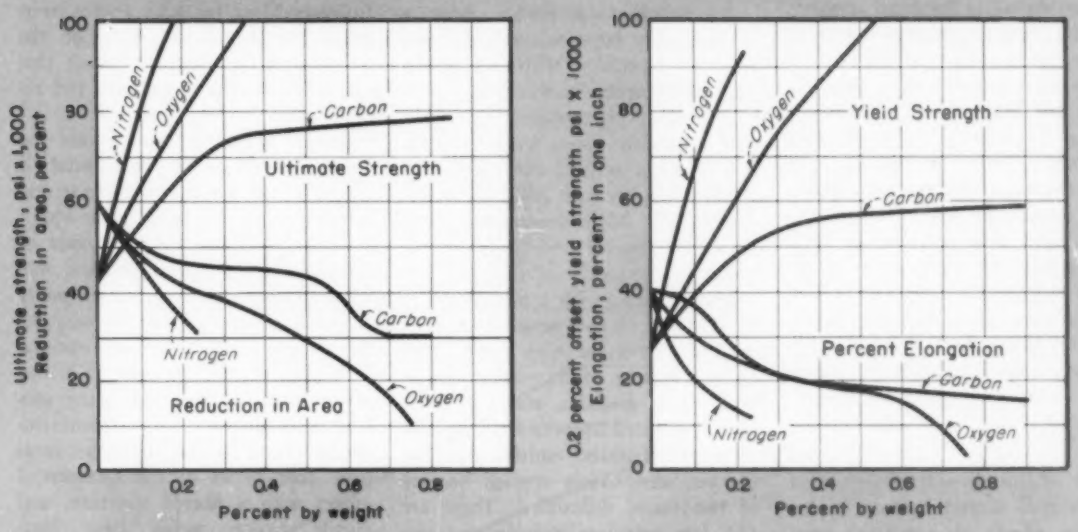


Fig. 2—Effects of carbon, oxygen and nitrogen on mechanical properties of high-purity titanium.

Table II—Reflectivity of High-Purity Aluminum and Other Metals

Material	Total Reflectivity, %	Reflectivity Content	
		Specular, %	Diffuse, %
Polished 99% Al	72	92.0	8.0
Brytal-treated* 99% Al	65	80.0	20.0
Brytal-treated* 99.99% Al	84	99.0	1.0
Stainless Steel	60	97.0	3.0
Chromium Plate	63	99.7	0.3
Laquered Silver Plate	90	97.0	3.0

* Electropolishing and anodizing treatment

Table III—Percent Content by Weight of Impurities in Molybdenum

Element	Commercial Molybdenum		High Purity Moly, Cast Form
	Powder Metal Forms	Arc Cast Forms	
O_2	0.0019–0.015	0.0006	0.00020
H_2	0.00004	0.0009	0.00005
N_2	0.00080	0.0005	0.00020
C	0.00300	0.0440	0.00200
S	0.00400	0.0170	0.001–0.003
Fe	0.02000	0.0020	0.00100
Si	0.00200	0.0010	0.00050

Al, Mn, Cr, Cu, Pb, Bi, Mg, Ti, Ni each less than 0.001

electropolishing and anodizing which give the surface good corrosion and abrasion resistance. The carry-over of the high reflectivity in the surface even after dying treatments permits a wide variety of colored finishes having a lustre more brilliant than is possible with lower grades of the metal. Even when strengthened by alloying with small amounts of magnesium, this high grade aluminum offers a higher reflectivity with greater permanence than does any other commercial metal. Thus, a polished and anodized 0.5 percent magnesium alloy made using 99.99 percent aluminum has a reflectivity of 83 percent, as compared to about 65 percent for similarly treated metal of 99.5 percent purity. Sufficient importance has been attached to these characteristics that a series of new alloys based on this grade of metal have recently appeared on the market under the trade name Lurium (Reg. Trademark, Fromson Orban Co., Inc., New York City). Anticipated applications include ornamental trim for automobiles, refrigerators, TV sets, and other items where light weight and attractive finish are desirable.

Although aluminum of 99.8-99.85 percent purity is used for the manufacture of collapsible tubes, its greater hardness as compared to tin and lead, and the need for annealing are handicaps. By virtue of its high ductility and low hardness, the 99.99 percent aluminum is more suited to impact extrusion than the lower grades; lower die pressure results in reduced wear of tools. And, improved corrosion resistance allows it to be used for products with a wider pH range, particularly on the acid side. Compared to 2S aluminum, the four-9's grade shows marked superiority in corrosion resistance, as well as in heat and electrical conductivity.

Another application for 99.99 percent aluminum is electrolytic condensers. The French are using this material in foil form and claim that its adoption has resulted in fewer rejections during manufacturing, improved shelf life and lower leakage currents.

While 99.99 percent aluminum is

not being produced in this country, it is available in commercial quantities from abroad in the form of sheet, strip, rod, bars, and tubing; wire in soft, quarter-hard, half-hard and hard tempers; and as extrusions. Depending on the specifications of the particular mill products, the metal costs about two to three times as much as brass or copper of identical dimensions. Because of low density, it is possible to achieve a lower unit cost by using the high-purity aluminum in place of such metals as brass or copper. Manufacturers claim that the cost of this metal in the finished form is less than the cheapest competitive metals.

IRON

Some of the physical properties of iron are still suspect because of the unknown effects of impurities commonly present in the metal. As illustrated in Fig. 1, the magnetic permeability of otherwise highly purified iron is strongly controlled by carbon "contamination" in excess of ten parts per million. Trace impurities of sulphur and nitrogen show an equally deleterious effect on the permeability. Recently, studies at the National Bureau of Standards revealed that iron containing a total of less than 0.0015 percent metallic impurities is unusually soft, ductile and corrosion resistant. While the market for this quality iron may never be calculated on a tonnage basis, the information gained from such a product will be of permanent value.

MOLYBDENUM

As noted, most metals show a comparatively large tolerance for impurities, especially with regard to mechanical properties. For some metals, however, contaminants in excess of a few tenths or even hundredths of a percent can completely destroy ductility and render a metal glass-brittle. Molybdenum and chromium are typical members of this group.

Molybdenum, with a melting point of 4,750 F, is of great interest in the construction of high temperature engines because of its good strength, high elastic modulus, and low creep rates at elevated temperatures. Despite these potentialities, molybdenum has not yet been widely applied because of two major difficulties. These are (1) low oxidation resistance at elevated temperatures and (2) inability to take ductile fusion welds.

Great progress has been made to overcome the poor oxidation behavior by cladding with nickel or coating with molybdenum disilicide. The problem of weldments has also been the object of much study. One of the first obstacles to the solution of this problem was the unorthodox behavior of commercial grades. To develop useful room temperature bend ductility, both the powder metallurgical and the arc-cast grades of molybdenum must be cold worked to produce a fibered structure. This stands in marked contrast to most of the lower-melting-point metals which show maximum ductility in the fully recrystallized condition. But fusion welding of these grades overcomes the beneficial effects of the fibered structure with the result that the metal in both the fusion and recrystallized zone is embrittled.

Recent work has shown that the unusual behavior of this metal is largely a matter of purity in the second decimal place: By using either multiple vacuum arc melting methods or solid-state purification processes, molybdenum of exceptionally high purity has been prepared. Table III compares the composition of the pure material with that of two commercial forms of the metal. This high-purity molybdenum displays more room-temperature bend ductility in the cast form than does either of the commercial grades with a fibered structure, and ductile fusion welds have been made using resistance weld methods.

CHROMIUM

High resistance to oxidation makes chromium of potential interest as a material of construction for high temperature applications. Current research for the Air Force has shown that the "inherent" brittleness associated with the presently available grades of this metal is a function of impurity content. Arc-melted chromium prepared using a modification of the iodide process is amenable to fabrication by rolling or swaging, and chromium sheet has been obtained which can

Fig. 3—Commercial grade RC-70 titanium can be forged and machined to intricate shapes by conventional methods.

Rem-Cru Titanium, Inc.

Table IV—Mechanical Properties for Several Grades of Commercial Titanium

Material	Yield Strength, (0.2%), psi	Ult. Strength, psi	Elongation in 2 in., %
RS 40	50,000	65,000	28
RS 55	60,000	75,000	25
RS 70	75,000	90,000	22
RC 55	55,000	65,000	25
RC 70	70,000	80,000	20
Ti 75A	50,000	75,000	25
Ti 100A	75,000	100,000	22

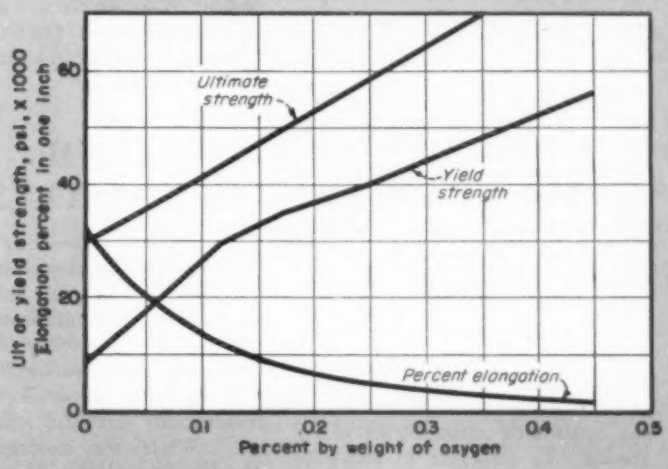


Table V—Thermal-Neutron Cross Sections

Element	Cross Section, barns
Beryllium	0.009
Magnesium	0.059
Zirconium	0.18
Aluminum	0.22
Tin	0.65
Zinc	1.1
Columbium	1.1
Iron	2.4
Molybdenum	2.4
Chromium	2.9
Copper	3.6
Nickel	4.5
Vanadium	4.7
Titanium	5.6
Manganese	13.0
Tungsten	19.0
Tantalum	21.0
Cobalt	35.0
Silver	60.0
Gold	94.0
Hafnium	115.0
Mercury	380.0
Cadmium	2,400.0

Fig. 4—Effect of oxygen on strength and elongation of high - purity zirconium.

withstand a 180 deg bend at room temperature.

While the above-mentioned advances in the metallurgy of molybdenum and chromium are noteworthy, neither of these metals is likely to reach the market in the immediate future in the quality required to exploit their most advantageous properties on an economical basis.

TITANIUM

"Iodide" or "crystal bar" titanium prepared on a laboratory scale contains less than 0.1 percent total impurities, is highly ductile, and has low yield and tensile strengths (Table I). While this metal represents the highest purity available, minute variations in the amounts of the contaminants at these levels often cause significant variations in the mechanical properties. Fig. 2 illustrates the effect of the most common contaminants. Carbon, oxygen, and nitrogen—in that order—increase the strength rapidly while lowering the tensile elongation. With its normal low complement of impurities, however, iodide titanium is characterized by its low strength and high ductility.

Only one basic process is being used for the commercial preparation of the metal. This Kroll process yields a sponge product by the reduction of titanium tetrachloride with liquid magnesium. While the impurity content is usually less than a total of 0.5 percent, the mechanical properties of the available grades reflect the sensitive effects of contaminating elements. Table IV shows the nominal mechanical properties of commercial grades. Small amounts of oxygen, carbon and nitrogen are not objectionable, and, in fact, for present applications, they are often regarded as necessary additions to enhance strength while still maintaining ductility to a useful degree.

The major advantage of titanium in structural applications is its relatively low density of 0.162 lb per cubic inch. Comparison with other metals on an equal strength-to-weight ratio shows that the tensile strength is about equivalent to the stainless steels and higher-strength aluminum alloys. While the strength of titanium remains at a high level up to about 600 F, the annealed metal does show unfavorable room-temperature creep behavior. At about 80 F, titanium shows creep at loads as low as 60 percent of yield strength. This figure can be improved to about 80 percent by cold working. However, at temperatures from 400 to about 700 F, stresses considerably above the yield strength must be imposed to produce appreciable creep.

Several other important properties are demonstrated by the commercially pure grades of titanium. They have a

flexural endurance limit consistently in excess of 50 percent of tensile strength. Toughness and ductility in ballistic-impact tests have shown promise as armament. They also show good resistance to corrosion by a variety of chemical reagents and are impervious to chloride solutions.

Despite the reactivity of titanium with oxygen and nitrogen, massive forms of the metal can be handled in air at temperatures up to 1,800 F without excessive contamination. Titanium can be hot worked readily and forged to intricate shapes, Fig. 3, using conventional practices. For heat treating thin sheets or wire, either vacuum or inert atmosphere furnaces are required. Under similar conditions, sound ductile welded joints can be obtained by inert-arc, spot, seam and flash welding. Oxyacetylene or unshielded arc methods are not used.

ZIRCONIUM

The development of zirconium has closely paralleled the path of titanium These metals show a strong similarity in many of their chemical and mechanical properties, and essentially the same procedures are used in their preparation and handling. While the strengths of the two metals are comparable, zirconium (density of 0.23 lb per cu in.) is nearly half again as heavy as titanium.

The major stimulus responsible for the growth of zirconium has been its low thermal-neutron cross section (i.e. low tendency to absorb or capture thermal neutrons). This relatively new parameter has arisen with the advent of atomic energy and the subsequent search to generate useful power from nuclear fission by thermal reactors. As shown in Table V, zirconium has a lower cross section than any of the other commonly available structural metals excepting magnesium.

Prior to 1947, the accepted value of the thermal-neutron cross section of zirconium was about 3.5 barns. Work since that time has shown that the true value is about 0.18 barn and has established that the discrepancy resulted from the presence of 2.0 to 3.0 percent hafnium, normally present in a Siamese-twin relationship with natural zirconium.

With regard to mechanical properties, high purity zirconium shows about the same degree of sensitivity to contamination by oxygen, nitrogen and carbon as does titanium. Fig. 4 illustrates the effect of oxygen on mechanical properties. Again, small quantities of oxygen and other contaminants normally found in Kroll-process metal can be regarded as beneficial additions. Table VI shows the mechanical properties of commercial grade zirconium.

Corrosion resistance is another of the outstanding characteristics of zirconium. Its resistance to attack by alkalis is excellent; corrosion by nitric acid in all concentrations and temperatures up to 100 C is negligible. Zirconium also shows excellent resistance at all temperatures in sulphuric acid solutions up to 80 percent, and in hydrochloric acid, its behavior is only slightly inferior to tantalum.

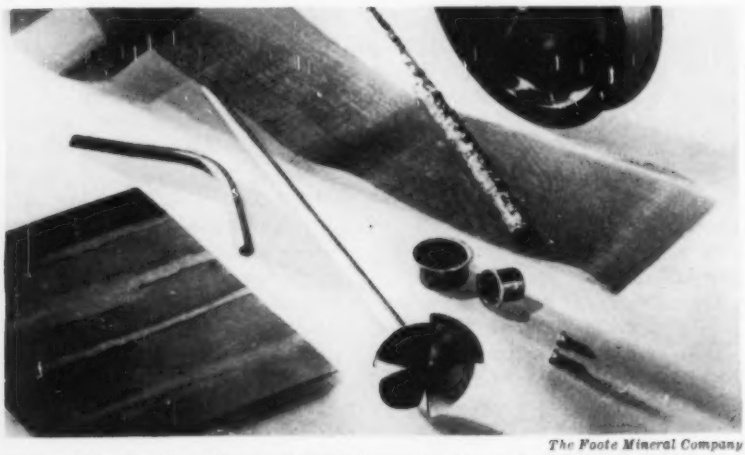
Table VI—Mechanical Properties of Kroll Process Zirconium

Proportional Limit, 0.01% offset, psi	16,900
Yield Strength, 0.2% offset, psi	29,200
Ultimate Tensile Strength, psi	49,000
Modulus of Elasticity, psi	13,700,000
ardness, R_B	83

The metal can be forged, rolled, spun, cupped, and drawn as illustrated in Fig. 5. It can be joined by fusion or spot welding using procedures similar to those developed for titanium. Since zirconium is about equally susceptible to hot-air contamination as is titanium, the same precautions concerning hot working in air must necessarily be observed.

FUTURE OF PURE METALS

The potential prospects resulting from improved quality metals are, as yet, largely unrealized. For some of the relatively few unexploited metals, such as chromium, utility of the massive form in the unalloyed state may well depend on the development of a commercially successful refining process. While the majority of the metallic elements have been isolated in a sufficiently pure state to characterize their principal properties, the full effects of trace impurities on these properties is not yet known. It is therefore likely that new uses for "old" or little-used metals will continue to develop. The possibility also exists that further improvements in the quality of existing commercial metals will be carried over into the alloys of which they form a part. This might not only benefit existing alloys, but also aid in future alloy design by allowing a more proper choice of metals to fit required performance.



The Foote Mineral Company

Fig. 5—Zirconium is readily forged, rolled, spun and drawn in a wide variety of shapes.

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PROPERTIES OF

Preloaded Steel Bolts

Behavior of preloaded steel bolts in assemblies that are loaded in direct tension and shear. Tension induced by applied torque and torque-tension ratio. Relaxation of initial bolt tension in service. Factors that affect fatigue strength and life of steel bolts that are subjected to repeated impact loads.*

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MANY DESIGN PROBLEMS are associated with the use of steel bolts, but perhaps the most important one is how to obtain and maintain an adequate clamping force on the bolted parts.

The function of preloading is indicated in Fig. 1. The preload *P* is the tension force developed in the bolt shank by wrenching the bolt head or nut or by stretching the bolt in some assembly operation. The forces *T* and *S* are the tensile and shear forces, respectively, applied to the bolted structure by service loads.

When the bolted materials are well fitted and are of steel so that they are rigid as compared with the material in the bolt, the tension in the bolt remains at the preload value *P* until the resultant of the applied tension forces *T* on the bolt exceeds *P*. No separation of the parts or further extension of the bolt occurs as long as the preload on the bolt is greater than the resultant of the applied tension forces or loads.

When compressible gaskets separate the bolted parts, or when the bolted materials have a low modulus of elasticity such as that of magnesium or aluminum, the bolt load will be increased beyond the preload value as tension is applied to the structure.

Similarly, when shearing forces *S*, Fig. 1, are applied to the structure, the joint does not slip if the frictional resistance between the parts as produced by the preload tension *P* is not exceeded by the shearing forces. If the joint does not slip, no shear or bearing load is applied on the bolt, nor does the tensile load change from its initial preload value. The slip point is determined by the coefficient of friction of the bolted parts and the amount of preloading on the bolt.

Bolts can be preloaded in several ways. Large bolts are often drilled along the axis for the insertion of a heating element. When heated to a predetermined temperature, the bolts are lightly torqued in place. In subsequent cooling of the bolt, the thermal contraction induces preloading, the amount of which is dependent upon the temperature at which the bolts were torqued.

In another preloading technique, hydraulic jack arrangements are used to stretch large bolts for easy assembly of the nut. On release of the jack, its load is transferred to the nut. Other techniques use direct drive and impact power devices for tightening. Also, bolts often are tightened with hand wrenches equipped with a measuring device that indicates the torque applied during wrenching.

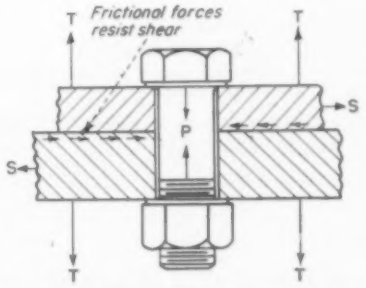


Fig. 1—Bolt preload P resists tensile forces on structure and clamps the parts together. Shearing forces S are resisted by frictional forces on clamped parts.

Where precise preloading of bolts is required, the amount of preloading is usually determined by measuring the elastic extension of the bolt as the bolt or nut is torqued.

* The material in this article is a condensation of the author's manuscript "Bolted Joints," which will be included as a chapter in an ASME handbook "Metals Engineering—Design" soon to be published by the McGraw-Hill Book Company.

TENSION INDUCED BY APPLIED TORQUE

Only a small percentage of the applied torque induces tension in the body of the bolt. Most of the applied torque is consumed in friction on the bearing face of the bolt head or nut and on the bearing surfaces of the mating threads and produces no tension whatever. Since the coefficient of friction is variable, the relation between torque and tension will be almost proportionately variable.

To determine the variation of the torque-tension ratio, Maney (Ref. 1) tested a large number of bolts and nuts made by several manufacturers. The bolts were of stress-relieved low-carbon steel and had cold-formed threads. The nuts were of American Standard regular proportions, semi-finished. Bolts and nuts in each size and thread pitch were assembled between the heads of a tension-testing machine. In each test, a measured torque was applied and the corresponding load on the bolt, as indicated on the machine dial, was observed.

From these data, the average torque coefficient (lb-in. torque per in. of bolt dia per lb bolt tension) was calculated and found to be substantially constant for all diameters and for both coarse and fine threads. The average coefficient at high torque was 0.191, and at medium torque was 0.201.

Where

d = bolt dia, in.
L = bolt load in tension, lb
T = applied torque on bolt head or nut, lb-in.

It seems fair as an estimate, therefore, to assume that

$$T = 0.2\,d \times L$$

In a group of, say, 25 bolts it may be found that an extreme bolt will depart from the average by some 30 percent. Maney found the mean deviation from the average to be about 7 percent. These data, of course, apply only to bolts and nuts in the stated condition. The torque coefficient will vary with variations of surface conditions such as plating and lubrication.

Lubricants are available that, when applied to the parts, will reduce the torque coefficient as much as 50 percent.

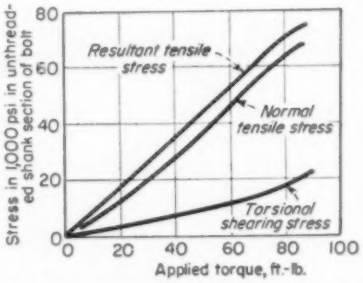


Fig. 2—Tensile and torsional shearing stresses in shank of stress relieved 1020 bolts induced by torquing nut on the bolt.

When a nut is torqued on a bolt, Maney (Ref. 2) has shown that there is not only a normal tensile stress induced in the bolt, but a torsional shear stress as well. This torsional shear stress results from the friction between the threads as the nut is turned, which consumes about 45 percent of the applied torque. The results of a measurement of these stresses by electrical strain gages attached to the shank of stress-relieved 1020 steel bolts are shown in Fig. 2. The normal tensile stress is the stress providing clamping force or bolt preload.

Because of the concurrent torsional shearing stress, the resultant tensile stress in the bolt is higher than the normal stress. If the bolt were torqued to failure, therefore, it would break at a load lower than that which would cause failure under direct tension. It is probable that a stress relieved 1020 steel bolt should not be depended upon to produce a clamping load greater than about two-thirds of its tensile strength. When the yielding is not sufficient to cause excessive distortion of the fastener, however, torquing until the bolt begins to yield should not cause damage. Such yielding of the bolt probably is beneficial if not carried to failure in assembly.

While a bolt fails under torque at less than its direct tensile strength, Hill (Ref. 3) has shown that the ultimate strength has not been reduced by torquing. If a bolt were torqued to a point less than the torque failure load, then the subsequent load in direct tension to break the bolt is the same as it would have been were the bolt pulled without torquing. This observation indicates that, even if the bolt is tightened to just below the failure point, there is still a considerable reserve strength in subsequent service.

In view of the importance of preloading, attention should be given to the maintenance of the preloading throughout the life of the equipment in which the bolt is assembled. It is probable that the bolt tension relaxes to some extent in service.

RELAXATION OF INITIAL BOLT TENSION

Relaxation may result from the flattening out of rough spots on contact surfaces or from the extrusion of dirt, paint, or plating from contact surfaces. There also may be a flow of metal at local points of high stress. When testing high-tensile steel bolted structural joints in fatigue with load shear-directed with respect to the bolt and with hot-rolled mill-scaled plates, Lenzen (Ref. 4) found 18 percent loss in tension in 3 speciments and 0 to 13 percent loss in 10 other specimens.

Relaxation of initial tension might also occur in service either by crushing of the bolted material under the bearing face of the bolt head or nut or by crushing of bearing faces of the bolt or nut. The degree of such crushing will depend upon the net area of bearing face in contact, Fig. 3, and the relative physical properties of the bolt and bolted material. The contact bearing area of the bolt head or nut should be sufficient to prevent the fastener material from crushing under the maximum bolt load. Even so, the bolted material may crush if hard fasteners are used in softer bolted parts, unless extra contact area is provided either by the fasteners themselves or by the addition of a washer harder than the bolted material.

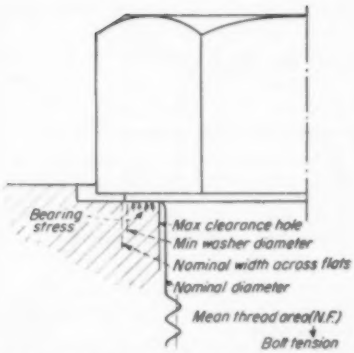


Fig. 3—Area of bearing face between bolt head or nut and surface of bolted part.

As mating surfaces adjust themselves, relaxation reaches a stable value with bolt tension somewhat less than the initial preloading. For this reason, where preloading is of critical importance, the size of the bolt should be such that the bolt can be preloaded to a value in excess of requirements, thereby providing for anticipated relaxation.

The loss of elastic elongation of the bolt as a result of relaxation is generally a fixed amount regardless of total grip length. The effect of relaxation, therefore, is more important in short bolts than in long bolts, since long bolts are assembled with a greater amount of compensating elastic elongation.

Additional elastic elongation is often provided in bolts and studs by "waisting," or reduction of the unthreaded portion of the bolt. This reduction in section does not weaken the bolt below that of the threaded section but results in higher tensile stresses in the shank and consequently greater elastic elongation.

No investigation is known that evaluates the elastic deformation of threads by bending and by elastic distortion of the nut, which occurs in either fine or coarse threads, but its magnitude is probably comparable with that occurring in the body of the bolt.

The first thread inside the nut takes a higher than average load. This high load on the first thread produces bending stresses at the root that are additive to the normal tension stress. One procedure for reducing this high load is the use of reverse taper of the bolt thread. The same effect could be obtained by slightly shorter pitch of bolt threads compared with those of the nut, but this difference in pitch would be difficult to hold in production. It is probable that high torquing of the nut will plastically deform this first highly loaded thread and at low bolt tensions the load will be more uniformly distributed in the nut threads. Almen (Ref. 5) discusses the benefit of such stressing; in the article referred to he points out that overloading the bolt initially results in residual compression at the thread root.

FATIGUE AND ENDURANCE LIFE

In applications where loading is tension-directed with respect to the bolt, Almen has shown (Ref. 6) that the endurance life of a bolt in comparatively rigid parts increases rapidly as the bolt is progressively tightened, Fig. 4, and becomes infinite as the initial bolt tension approaches the maximum bolt load applied to the assembly. The reason for this improved endurance life is that increasing preloading reduces the amplitude of stress change in the bolt to a safe value, provided that the bolted material is comparatively rigid. This resistance of the bolt to fatigue is dependent solely upon the preloading of the bolt and is not affected by factors such as surface conditions of the bolt or similar stress raisers that might otherwise lead to early bolt failure.

When the amplitude of stress change in the bolt is excessive, Goodier and Sweeney (Ref. 7) demonstrated that there is a tendency for the nut to loosen. Proper preloading of bolts and proper design of bolted parts reduce the amplitude of stress change and thereby provide a locking effect.

With low-modulus compressible structural materials, such as magnesium, Milliken (Ref. 8) emphasizes that there is an "optimum" preload of bolts. Further preloading does not reduce the stress cycle in the bolt but merely increases the average stress and susceptibility to fatigue. Even here, however, some excess of preload is helpful in compensating any loss of tension in service.

Rounding of thread roots increases endurance limit. Schwartz (Ref. 9) compared the endurance limit of a special thread having a very large radius with that of standard threads. In specimens designed to eliminate effects of difference in thread depth, he found endurance limit as a percentage of tensile strength to be 17.5 for American National, 20.2 for British Whitworth, and 27.4 for the special thread.

Bolts subjected to repeated impact are often necked down in the body to increase flexibility and to improve impact fatigue resistance. In Table I are given data compiled by Staedel (Ref. 10) for bolts of five different body diameters and three different bolt steels. These data show large increases in repeated impact fatigue resistance as the bolt body is progressively reduced. In the extreme, as the body is reduced, failure may take place in the body rather than the thread section. To reduce the danger of such failure, the body may be shotpeened.

Decarburization of stressed surfaces may reduce the endurance limit. It

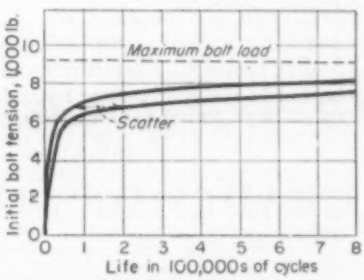
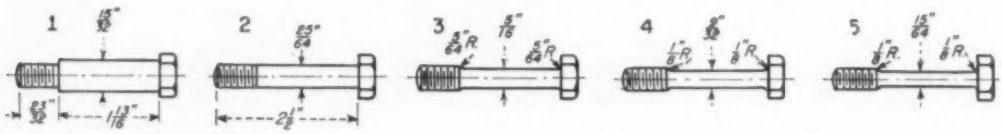


Fig. 4—Effect of initial bolt tension or the preload on the endurance life of a bolt that is dynamically loaded in tension.

is doubtful, however, that the depth of decarburization is related to the reduction of fatigue strength. Fatigue failure is a tension failure beginning at the bolt surface. Decarburization decreases the tensile strength at the surface. Once a crack starts at the surface, the crack becomes a stress raiser

Table I—Effect of Body Diameter of Bolt and Bolt Steel on the Repeated Impact Fatigue Strength of Bolts



Bolt Design	Bolt Body		Repeated impact fatigue limit					
			Steel A		Steel B		Steel C	
	Area, sq in.	Area in percent of area at root of thread	in.-lb	Percent of Design 3	in.-lb	Percent of Design 3	in.-lb	Percent of Design 3
1	0.173	225	1.73	38	1.73	62		
2	0.120	156	2.60	60	2.26	81	≈2.17	63
3	0.077	100	4.34	100	2.78	100	≈3.47	100
4	0.062	81	5.21	120	2.95	106	5.21	150
5	0.043	56	6.51	150	3.65	131		

Steel	% C	% Mn	% P	% S	% Si	Ultimate, psi	Yield, psi	Elongation, percent	Reduction area, percent	Bolt * Ultimate
A	0.15	0.65	0.095	0.186	0.04	78,200	.....	12.8	56.0	93,900
B	0.25	0.75	0.019	0.024	0.25	96,400	.....	12.8	54.0	118,900
C	0.33	0.70	0.039	0.027	0.18	85,300 to 99,600	>68,300	16 to 10	....	118,000

* Static tensile strength of actual bolt, Design 2, having 5/32-in. length of free threads under nut.

and continues even through full-carbon material. A small depth of decarburization, therefore, probably affects fatigue as much as a larger depth. Since wire for the production of bolts usually cannot be obtained free of decarburization, elimination of decarburization requires a machining or grinding operation. Alternatively, carbon can be restored by some method.

Cold working of stressed surfaces improves fatigue resistance. Processes such as rolling thread roots, shot-peening shanks, or rolling of fillet between head and shank harden the respective surfaces and leave these surfaces in a state of initial compression.

In his discussion of processes that reduce the vulnerability of screw threads to fatigue failures, Almen (Ref. 5) demonstrates the improved fatigue resistance obtained by rolling threads completely, superficial rolling of thread roots after previous forming of threads, and prestress of thread roots by stretching the bolt.

Investigations by Green (Ref. 11) indicate that cold rolling the fillet under the bolt head results in a five-fold increase in endurance life.

GRADES OF STEEL BOLTS

Bolts and nuts, of course, are made from a variety of materials and by a variety of processes. In some applications the exact chemical composition of the material is important, such as where corrosion is a factor. Also, there are occasions where composition and metallurgical treatment must be closely determined so as to get a special service result that otherwise cannot be controlled readily. In such instances, control of composition and treatment is customary.

In the ordinary usage of steel bolts and nuts, however, the exact chemical composition of the material and the process of manufacture are of little interest to the user, provided that service requirements are met. In fact, it is a mistake to limit these production factors in specifications, since it reduces the flexibility of production control in the manufacturer's plant and results in unnecessarily high costs. What should be done is to specify the requirements in terms of useful service factors and leave material and manufacturing procedure to the producer.

Further, to simplify production, it is desirable to select a standard physical grade of bolt rather than to pick at random a set of physical properties. Grades of steel bolts as standardized by the SAE and the ASTM are given in Table II.

Grade 0 is merely a reference for drawings where no particular mechanical properties are required.

Grade 1 includes low-carbon steel, hot-forged, or cold-forged and stress-relieved at a relatively high temperature. The high-temperature stress relief of cold-forged bolts is usual when large cold upsets are made, such as for square-head bolts, carriage bolts, and similar bolts.

Grade 2 is widely used in automotive practice as a cold-headed hexagon-head bolt. Since the hexagon head is not severely cold upset, it is stress-relieved at a lower temperature such that will prevent head failure but not completely soften the bolt. The resulting product, therefore, retains much of the strength benefit of the cold working.

Grade 3 is a medium carbon steel bolt, cold-worked by extrusion of the blank and roll threading. This bolt may be aged at about 700 F to meet required mechanical properties. Jameson, Halgren, and Sheridan (Ref. 12) refer to the possibility that this bolt may have application where higher fatigue strength is required and where a high stress cycle in the bolt cannot be avoided by joint design. The bolt as compared with Grade 5, however, has limitations as to ductility and ultimate strength.

Grade 5 may be used where high preloading of the bolt is practical. It is a quenched and tempered medium carbon steel bolt and is most economical where the highest clamping force per dollar of cost is desired. ASTM A325 describes substantially the same bolt, though the prescribed limits are slightly different.

Grade 6 is a special medium carbon steel bolt, quenched and tempered, usually having a somewhat higher manganese content. It is useful where properties higher than those of Grade 5 are required without the expense of alloy steel.

Grade 7 is an alloy steel, quenched and tempered, used particularly where threads are to be cold-rolled after heat-treatment to get improved fatigue strength. This bolt has about the highest hardness capable of thread rolling after heat-treatment.

Grade 8 is also an alloy steel, quenched and tempered, but is of higher strength than Grade 7.

There are special applications where still higher physical properties than those shown above are required. The use of such bolts, however, is special and requires considerable care in the manufacture of the bolt and in the preparation of the bolted material.

Table II—Grades of Steel Bolts

Properties given are for sizes ½ in. dia. and smaller. For complete data and for properties of larger bolts, see SAE Handbook and ASTM specifications.

SAE Grade	ASTM Designation	Tensile strength, psi	Proof load or yield strength, psi	Material
0	....	.....	.....	Low carbon
1	A 307	55,000	.....	Low carbon
2	....	69,000	55,000	Low carbon, stress-relieved
3	....	110,000	85,000	Medium carbon, cold-worked
5	....	120,000	85,000	Medium carbon, quenched and tempered
	A325	125,000	90,000	Medium carbon, quenched and tempered
6	....	140,000	110,000	Special medium carbon, quenched and tempered
7	....	130,000	105,000	Alloy steel, quenched and tempered
8	....	150,000	120,000	Alloy steel, quenched and tempered

The principal function of the nut is to load a bolt, and a grade of nut should be selected depending upon the bolt to be used. Nuts may be classified by their stripping strength, which is determined by engaging the nut on a hardened and ground threaded mandrel and then pulling the mandrel through the nut. The major diameter of the mandrel thread determines the shearing area in the nut thread and must be closely controlled. The stress at failure is determined by dividing the load by the so-called "stress area" (mean thread area) of the threaded section.

Common nuts will withstand a strip test of this variety of about 90,000 psi. For higher strength bolts a nut of higher stripping strength is required, but its hardness should be kept as low as possible consistent with the required stripping strength. This precaution permits the nut threads to conform to those of the harder bolt without excessively loading any thread.

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Special Purpose Mechanisms

Fig. 1—Spherical linkage, produces an oscillating rotational output from a constant speed input for an input angular displacement

$$\tan \psi = p \sin \phi,$$

where ψ = output angular displacement, and

$p = \tan \alpha$, where

α = constant angle between roller shaft b and input axis c.

For mechanism to function properly, axes of semicircular link d, of roller a, and of input shaft e must intersect at point M.

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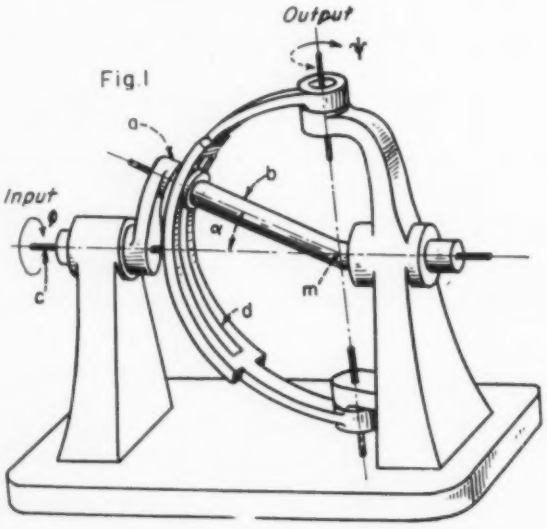
Ford Instrument Company
(Div. of The Sperry Corporation)



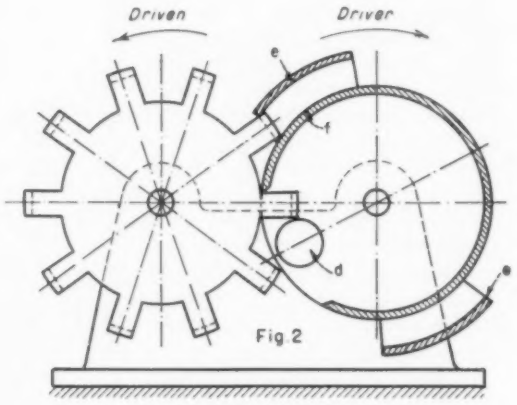
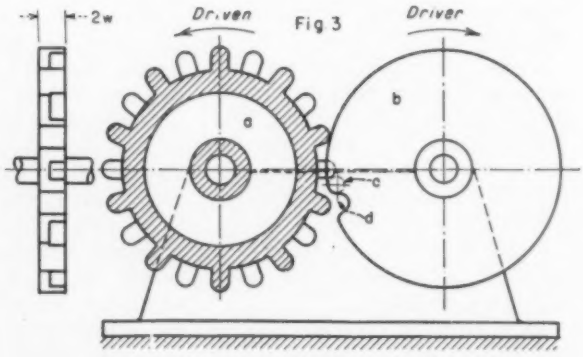


Fig. 2—Intermittent drive with cylindrical lock. Shortly before and after engagement of two teeth with driving pin d at the end of the dwell period, the inner cylinder f is not sufficient to effect positive locking of the driven gear. A concentric auxiliary cylinder e is therefore provided with which only two segments are necessary to get positive locking. Their length is determined by the circular pitch of the driven gear.

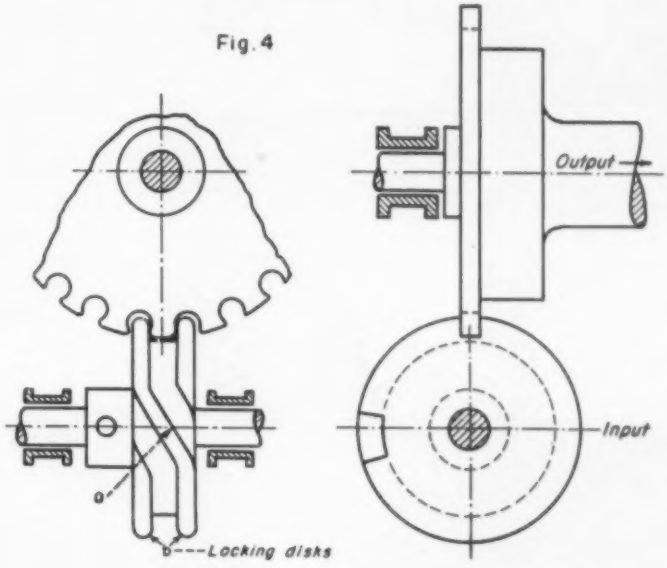
Fig. 3—"Mutilated tooth" intermittent drive. Driver b is a circular disc of width w with a cutout d on its circumference and carries a pin c close to the cutout. The driven gear, a of width $2w$ has standard spur gear teeth, always an even number, which are alternately of full and of half width (mutilated). During the dwell period two full width teeth are in contact with the circumference of the driving disc, thus locking it; the mutilated tooth between them is behind the driver. At the end of the dwell period pin c comes in contact with the mutilated tooth and turns the driven gear for one circular pitch. Then, the full width tooth engages the cutout d and the driven gear moves one more pitch, whereupon the dwell period starts again and the cycle is repeated. Used only for light loads primarily because of high accelerations encountered.



Data based on material and sketches in AWF und VDMA Getriebeblaetter, published by Ausschuss fuer Getriebe beim Ausschuss fuer wirtschaftiche Fertigung, Leipzig, Germany.

Fig. 4—Mechanism for transmitting intermittent motion between two skewed shafts. The shafts need not be at right angles to one another. Angular displacement of the output shaft per revolution of imput shaft equals the circular pitch of the output gear wheel divided by its pitch radius. The duration of the motion period depends on the length of the angular join *a* of the locking discs *b*. This drive was used extensively on motion picture projectors. Two other drives, used to move the film intermittently in projectors, are shown in Figs. 5 and 6.

Fig. 4



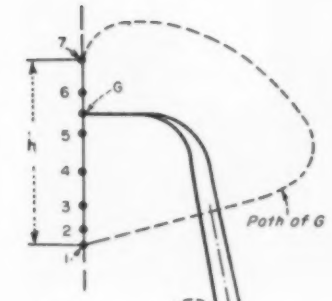


Fig. 5

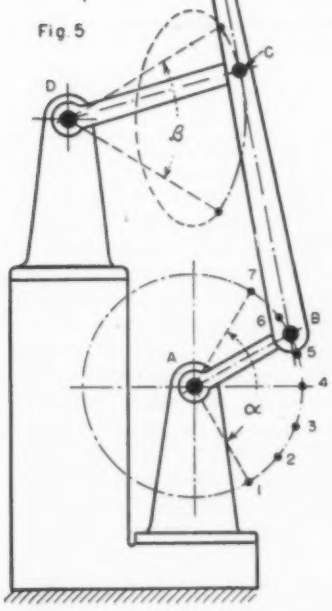
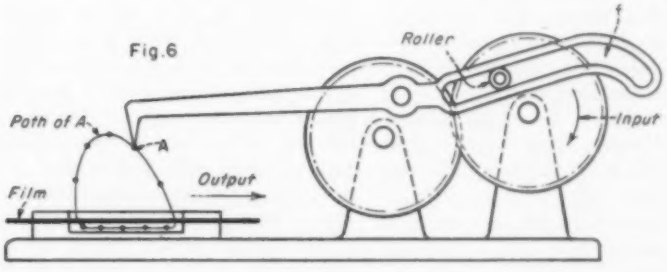


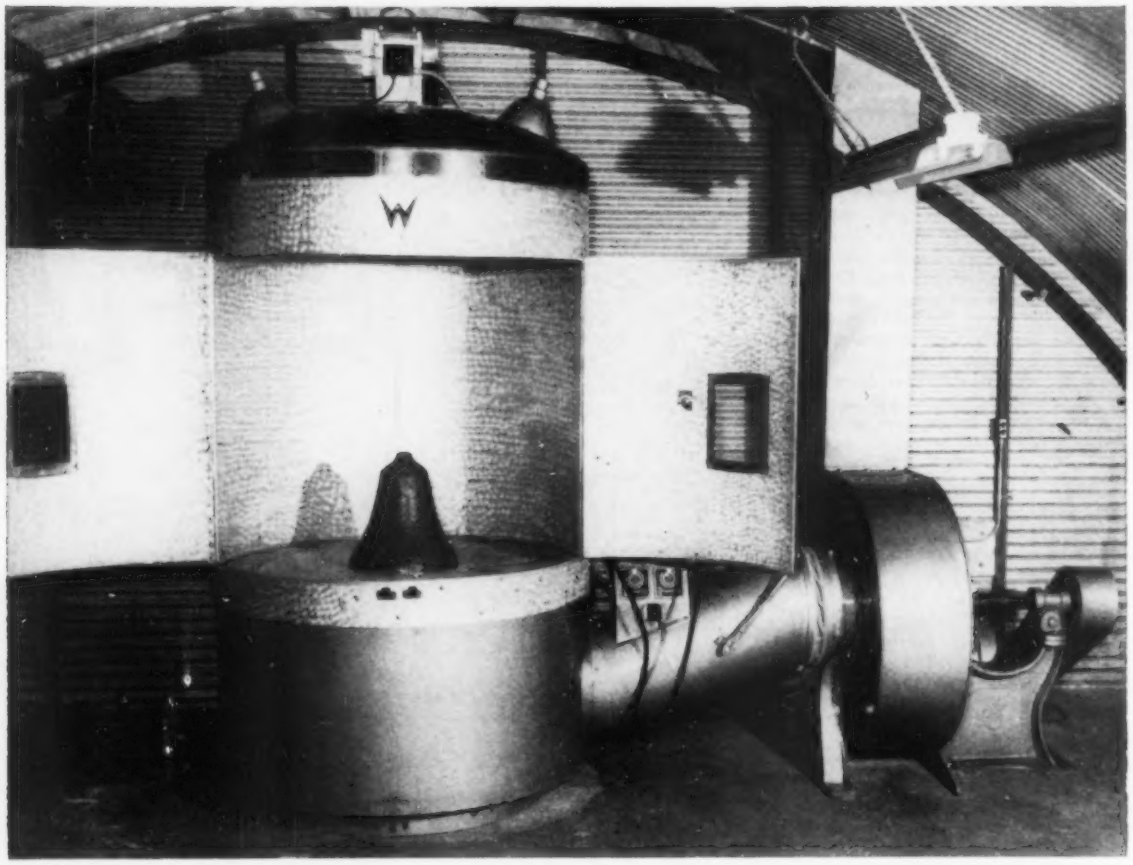
Fig. 5—The task of describing a "D" curve, as accomplished by a mechanism of Fig. 6, can also be achieved by this four-bar linkage. Hint for designing: Start with the straight line portion of the path of *G*, replace the oval arc of *C* by an arc of the osculating circle, thus determining the length of link *DC*.

Fig. 6—This mechanism is intended to accomplish the following: (1) Film hook, while the film strip, must describe very nearly a straight line; (2) Engagement and disengagement of the hook with the perforation of the film must take place in a direction approximately normal to the film; (3) Engagement and disengagement should be shock free, Slight changes in the shape of the guiding slot *f* enable the designer to vary the shape of the output curve as well as the velocity diagram appreciably.

Fig. 6



TECHNICAL NEWS



PREFORMING UNIT, with doors open; uses metal perforated screen to shape reinforcing material. Air exhausted through the holes draws pieces of fiber glass onto the mold (a decorative bell, above) which rotates slowly on turntable.

PLASTIC PREFORMING

HOUSTON—To make plastic parts reinforced with glass fibers more easily, L. C. Williams and Associates have perfected a new technique and developed necessary equipment for preforming the reinforcing material to the desired shape. The method—similar in some respects to felt hat making—uses chopped strands of fiber and eliminates hand layup.

Briefly, here's how the process works. Vacuum sucks chopped glass roving onto a screen shaped like the desired part. At the same time, a binding agent is sprayed as a mist into the chamber, while the preformer screen rotates. Air pressure holds the fibers onto the shape and helps compress them to form a more compact mass. The shaped part is dried and cured. A weatherproof glazing coat, if desired, of polyester resin is then sprayed on and cured in an infra-red oven.

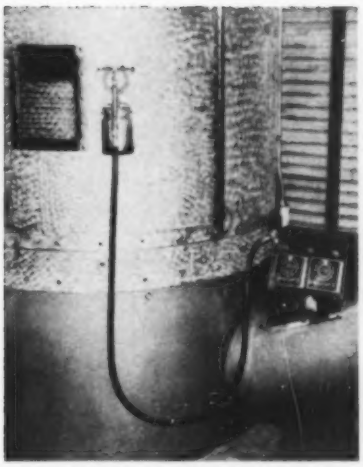
The screen that collects the fibers is made of 16 gage steel or Muntz metal perforated with $\frac{1}{8}$ in. holes through which air is exhausted. Chromium steel screens have a smooth surface that readily releases the fibers and does not corrode. However, some binding agents make it difficult to release the preformed shape from the screen. When that happens, the mold is first sprayed with a release agent, like Teflon, applied as a water emulsion or enamel.

What binding agent is used depends on the design of the part and the properties that it must have. For such items as decorations that need a minimum amount of strength, an ethyl cellulose solution will hold the glass strands together sufficiently so they can be handled. A glaze coating of plastic supplies enough strength to the finished product and makes the part weather-proof. If the part must withstand considerable stress, polyester resins or thermosetting alkyd molding compounds can be used.

The latter two materials are well adapted to this technique: they require relatively low temperatures and pressures for curing, and they are true liquid plastics.

Another reason for using polyester

PROCESS STARTS when this chopper slices 60 strand glass roving into short two inch lengths.



BINDING AGENT is sprayed in as a mist and automatically cut off at a predetermined time set on these controls.

FINISHED PREFORM is removed on screen which is then separated. Binding agent holds fiber together.

resin, both as a binding agent and as glazing material, is the desirable color property of the plastic. That is particularly important in consumer items. In designing industrial products, the chief advantages are high strength, non-magnetic, and corrosion-resistant properties of the reinforced parts.

Williams' biggest preformer has only a 46 in. turntable opening. But the same process, carried out in a larger unit, could make automobile bodies. The technique is currently being evaluated by automobile makers.

Other experiments with the techniques are attempting to increase the number of plastics that work well for preforming. One group of interest includes such thermosetting resins as phenolics, epoxies, and silicones.

Chief limitation of the process is hollow shapes with undercuts or reversed curves that interfere with the removal of the mold.

Curtailing Patent Rights

WASHINGTON — Supporters of strong patent rights have suffered a severe setback as a result of a recent federal court decision. In it, the General Electric Company was ordered to "dedicate to the public"—which amounts to making a gift—all existing patents on the manufacture of electric bulbs and parts. This is the first time in the history of anti-trust legislation that such a broad blow has been struck at patent holders' rights to exclude others from use of a patent.

To observers in the nation's capital, this decision means that government antitrusters are trying out a new approach to what they call modern industrial monopoly. Their target: breaking up combinations of companies cornering the technology of an industry. Their weapon: wholesale divesture of exclusive rights granted under the patent laws.

Here is what it meant in the G. E. case:

The company must grant, without royalties, to any applicant, any or all existing G. E. patents on machinery used to make light bulbs. G. E. must grant, at reasonable royalties, to any applicant, any or all G. E. patents covering bulbs, parts or machinery developed in the next five years, provided that the applicant shares his own new developments with G. E., and G. E. has to supply any user of existing or future G. E. patents the full details—including blueprints—of how G. E. used the patent.

Inclusion of the patent dedication provisions in the judgment, written by Judge Phillip Forman (who also wrote the 1949 monopoly decision against the company), was the key demand pressed by government lawyers. G. E. opposed it on several grounds.

General Electric argues that manufacturers of products other than lamps would profit unfairly by the dedication. Two of the original eight companies charged with aiding G. E. maintain its monopoly signed consent judgments with the government earlier and are not directly affected by the judgment. So, says G. E., they and other competitors will be able to use G. E. patents without granting any of their own existing patents.

Perhaps of more economic significance, though, is G. E's position that manufacturers might use G. E. patents to make lamps for their own use, wiping out G. E. business and patent royalties in the same blow. For instance, automobile makers like Ford, G. M. and Chrysler, could now economically afford to make their own bulbs and parts with free G. E. patents. The same thing could apply to airplane manufacturers and others who incorporate electric bulbs into their own products.

But Judge Forman overruled these objections. He said dedication was imposed, not to punish G. E. for misuse of its patents, but to check competitive advantages gained through the misuse. On G. E.'s argument for reciprocal licensing on both dedicated and royalty-free patents, Forman said

such an arrangement would "perpetuate General Electric's dominance of the industry, which the judgment is designed to end."

The gist of the government's argument is this: We don't face a monopoly situation where somebody has cornered the market of a single product, but a monopoly of technology, far beyond the boundaries of legitimate exclusive use of patents. The result: a suppression of research.

Government attorneys feel they can support Forman's rulings as a "logical development from the Hartford-Empire case through National Lead and Alcoa."

In the Hartford-Empire case in 1945, the Supreme Court approved for the first time compulsory licensing on a reasonable royalty basis, in a glass-making machinery case.

Then in 1947, the Supreme Court approved some royalty-free licensing in the National Lead case—without saying it was possible in other cases. And in 1950, the antitrusters moved another step along the way in the Aluminum Company of America case. Alcoa had arranged to give royalty-free licenses to the Reynolds and Kaiser Aluminum companies. Kaiser and Reynolds were to reciprocate by "granting-back" to Alcoa their own patents. But the government pursuaded Federal Judge Knox to strike down the grant-back provisions in his monopoly judgment. This left Alcoa a royalty-free licensor by court action.

RUSSIAN TELEVISION SETS

RUSSIAN TV ENTHUSIASTS, if there are any, view their favorite programs on squint-provoking, midget screens that are reminiscent of U. S. television experiments conducted in the mid-thirties. Two Soviet sets have undergone intensive scrutiny at the Air Force's Air Technical Intelligence Center. ATIC's opinion: Soviet circuitry and design trail U. S. practices by about 10 years.

Most striking feature of both sets—one the Muscovite T-1, and the other the Leningrad T-2—is the small screen. Eight inches (measured diagonally from corner to corner) is the largest size screen Air Force intelligence officers could buy.

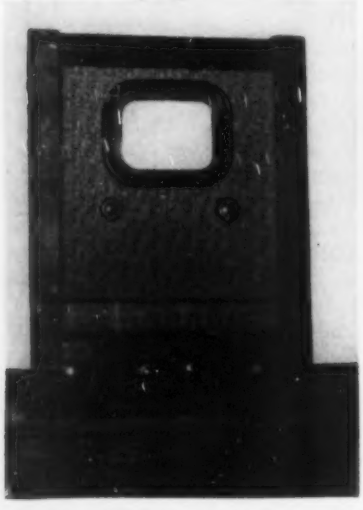
In 1948, the Muscovite marked Soviet entrance into television production. The design: a direct copy of a 1939 German receiver. Its features are hardly noteworthy. ATIC's set is a crudely built table model with a seven inch screen. It is capable of picking up only the Moscow channel, and, according to specialists, its best performance is only mediocre.

The Leningrad was the next development. The unit the Air Force bought was built in East Germany under USSR specifications for sale in Russia. It will pick up only the Leningrad telecasting station on its eight inch screen. The specialists rate this set's performance as fair. Sensitivity tends to be low, and synchronization, inferior. Speaker and power supply, on the other hand, are regarded as excellent.

A combination TV-radio, the T-2, has 32 vacuum tubes—26 associated with the TV circuit and six with the radio.

Although the Leningrad appears to have been built with assembly line methods, it is doubtful if production is very great. According to State Department figures, there are 12,500 sets in Russia. That's about one for each 16,000 persons. In the U. S., most recent statistics put the number of TV sets at close to 21,000,000—one for every eight persons.

One big obstacle barring widespread sale of Russian TV sets is the dearth of Soviet telecasting stations. The na-



FIRST TV SET built in Russia was the Moscovite T-1, a crudely-built table model with seven inch screen.

THREE YEARS LATER, East German electronics plants started building this improved eight inch combination radio-TV set for sale in Russia. English labels above operating knobs were placed there by Air Force electronic specialists who studied the sets.

tion's third station went on the air at Kiev last January, and its broadcasts are limited to weekends. Even though Moscow's population is over 4,000,000, the city has only one station.

Any attempt to compare Soviet sets with the U. S. units on a cost basis is difficult, because of the difference in types of labor available. But ATIC feels the Leningrad would cost at least $400 if it were built by an American manufacturer.

So far, the Air Force hasn't tried to receive any American telecasts with the Soviet sets. They've been too interested in the circuits and how the components were made. But they are willing to lend the receivers to any U. S. company that wants to make the necessary modifications.

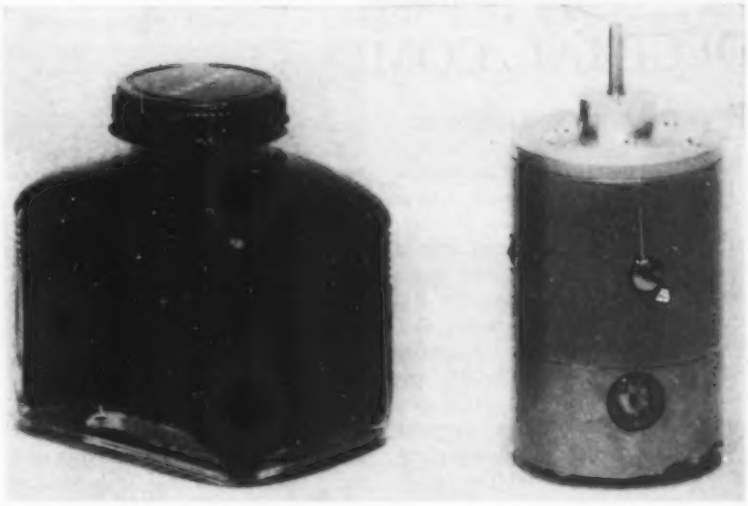
As for radios, ATIC experts have been studying a 1949 six-tube model manufactured for sale outside the U.S.S.R. Circuits are outdated, but performance is good. Cost to manufacture in the U. S.: about $45.

SHELL MOLDING PROGRESS

IF QUANTITY OF PLASTIC used is any indication, shell molding—the foundry process that casts precision parts from plastic-sand molds (*Product Engineering*, October, 1952, p 121, etc.)—is gaining popularity at an unprecedented rate. A major supplier of mold-making plastic, Monsanto Chemical Company's Plastics Division reports the industry's sales to foundries are up over 300 percent this year. It looks like even bigger boosts are ahead for the future.

From a supplier's viewpoint the growth of the shell molding process has been phenomenal. As recently as 1950 only insignificant amounts of phenolic went into shell molds. By 1952 the poundage had increased to three million per year. Estimates for 1953 range between eight and ten million pounds.

But such increases, big as they are, may be only the beginning. Even though new techniques have cut the amount of plastic required in the molds by 50 percent, Monsanto's market research people are betting on annual sales of over 50,000,000 lb of shell molding phenolic by 1957. That would make the process one of the biggest users of phenolics.



MINIATURE MOTOR

SMALLEST D-C MOTOR ever built by General Electric Company (above, compared to an ordinary ink bottle) plays an important role in Air Force bomber defense systems. Only $2\frac{3}{8}$ in. long, and $1\frac{5}{8}$ in. in dia, the 8 oz motor is rated at 0.002 hp at 6,500 rpm. A split-shunt, reversible-rotation type, it draws a maximum armature current of 0.8 amps from a 28 v line; is capable of responding to field currents as small as 0.00075 amps and can withstand a high potential of 1500 v.

Toughest problem in making the miniature power unit is winding 40,000 turns of 0.002 in. wire into coils. Over two miles of such wire goes into each motor.

FOREIGN NEWS

• HUNGARIAN MINING ENGINEERS have developed a coal combine—automatic cutter and loader—that they consider a major improvement over machines previously used in this Soviet satellite. Major design changes stress simplification, according to the Hungarian News and Information Services. In the new model, only two electric motors are required for power, instead of seven in one older design and four in another; the new coal digger is 13 ft long, 6 ft shorter than the smallest previous Hungarian machine; and it can be divided physically for separate uses as a cutter or loader.

• NEW CONTINUOUS WELDED RAILS, developed by Japan's National Railway Corporation's Technical Research Institute, will end much of the noise and jolting familiar to Japanese railroad passengers. State railways have started replacing 25 meter (about 75 ft long) rails with 1,000 and 2,000 meter length sections. Behind the elimination of the many rail joints is this thesis expounded by Yoichi Hoshino: Expansion by heat of a well-set rail is limited to only about 100 meters at each end; the middle of longer sections do not expand.

• LARGEST MACHINE TOOL ever designed and built in Great Britain is undergoing final tests by its manufacturer, Craven Brothers. The machine, a vertical boring and turning mill, weighs 650 tons; has a work turning table 41 ft in dia; and will handle work up to $42\frac{1}{2}$ ft in diameter, $13\frac{1}{2}$ ft in height, and weighing up to 100 tons. Thirty-two separate motors are used on the mill which will be exported to Canada, where it will fabricate turbine parts of hydroelectric installations. The machine occupies 3,700 sq ft of floor space and has an overall height of 40 feet.

DECIMAL COMPUTER

COMPUTERS have caught on like wildfire as an engineering aid, but the average engineer has been content to leave the application of such devices to specialists. One reason: all computers operate on the binary system of numbers which isn't too easy to get used to. Last month, Computer Research Corporation had news that would appeal to anybody unfamiliar with the binary system: CRC announced a simplified device that uses a decimal input. The new computer automatically switches to binary numbers for calculating, and then turns out decimal results.

The company claims their new machine, CRC 105 Decimal Digital Differential Analyzer, is as easy to operate as a standard 10 key adding machine. And it cuts filling time by 75 percent compared to older models. It can solve any problem that can be put in the form of a differential equation.

Actually, its capabilities are even greater than that. Other kinds of problems handled by the new device: (1) probability functions, (2) solution of integral differential equations, (3) solutions of non-linear systems, (4) algebraic linear equations, (5) partial differential equations, and (6) servo systems whose equations are unspecified.

CRC 105 indicates the current trend in computers—smaller, but versatile, easier-to-use, easier-to-maintain equipments that do not need specialists for operators. In this latest device, the electronics fit into a cabinet 38 x 72 x 90 in., little bigger than bookcase size; control switches and input-output media, including automatic typewriter and graph plotter and follower, require less space than the average sized office desk. Number of vacuum tubes in the device has been reduced to 400, still a large number but less than other computers developed for similar purposes.

Even though its size has been reduced, the computer remains a versatile machine. It can compute 60 increments of an independent variable every second. Its capacity—largest of all digital differential analyzers—is sixty integrators with a maximum accuracy of six digits and sign in each integrator. It can perform 3,600 integrations per second, and can work on as many as 20 different problems at the same time.

For memory purposes, the CRC 105 uses a magnetic drum that revolves at 3,450 rpm. Any one of the 60 integrators can receive information from as many as seven inputs: from other integrators, from outside sources (other computers, perforated tapes and graphs) or from itself.

Approximate cost of this device is $57,500. The company is building five units for the U. S. government.

DONALD C. McGRAW

DONALD C. McGRAW has been elected president of McGraw-Hill Publishing Co., Inc., succeeding his brother, the late Curtis W. McGraw.

Donald McGraw is the youngest son of the company's founder, the late James H. McGraw, Sr. He has been associated with the company since 1919. He has been a director since 1935, vice-president since 1945. During World War II, he was a consultant to the publishing and printing division of the War Production Board.

He joined McGraw-Hill in 1919 as an advertising staff member of the magazine Chemical and Metallurgical Engineering, which has since become Chemical Engineering.

Since 1933, when he was made company secretary and put in charge of production and manufacturing, he has been responsible for the handling of all contracts for printing and binding, engraving, and paper supply for the entire McGraw-Hill operation.

In 1945, he was named vice-president for manufacturing and general services, the position he has held until now.

News Briefs

• LOCKHEED AIRCRAFT Corporation is conducting a preliminary design study on nuclear-powered aircraft under a contract with the United States Air Force. No details, as yet, as to the scope of this project.

• A METALLIC BERYLLIUM FLAKE with high ductile properties is now available on a commercial scale from The Beryllium Corporation, Reading, Penna. The flake has a minimum purity of 99.5 percent. Its big feature, however, is its high ductility, which makes it particularly suited to fabricating applications such as hot pressing. Among other standard uses, pure beryllium is used for the windows of X-ray tubes and in applications involving nuclear energy.

• GENERAL ELECTRIC COMPANY plans to construct a $1.8 million combustion laboratory at Schenectady to aid scientists in obtaining knowledge needed to produce more powerful gas turbines for aircraft and other applications. Ground will be broken early next year, with completion scheduled for late 1954.

• ATOMIC ENERGY COMMISSION has approved the formation of a sixth team from private industry whose job will be to engage in power studies under AEC's Industrial Participation Program. The participants: Duquesne Light Company of Pittsburgh, Penna., and Walter Kidde Nuclear Laboratories, Inc.

NAVY'S NEW FACSIMILE PRINTER accepts copy without processing and turns out finished print that needs no wet developer. Device will transmit any document over long distances almost instantly.

NEW FACSIMILE GEAR

WASHINGTON—The Navy is trying out its own high-speed, low-cost facsimile equipment to transmit various kinds of documents instantaneously over long and short distances. While a new machine is now used for military purposes, its commercial applications eventually might outstrip those of the military.

The equipment fulfills two major requirements set by the Navy's Bureau of Ships: (1) Takes in copy without processing, and turns out finished copy without using a "wet" developer or extensive processing. (2) Delivers copies that can be directly reproduced on standard office offset-type reproduction equipment.

Previous equipment operating at the desired speed required the photographing of copy to be transmitted. It delivered copy on photographic film, requiring enlarging and printing before delivery to user. This means expensive equipment, skilled personnel, darkroom facilities, and adequate storage space—any one of which is often hard for Navy units to get.

The new equipment includes a sending unit and a receiving unit. Operating speed is 10 ft per min or ten $8\frac{1}{2}$ x 11 in. pages per minute.

The facsimile signal can be readily transmitted over concentric cable or, for longer distances, by radio relay. The video frequency band extends from zero to 100,000 cycles per second. In the present equipment this band is transmitted as an amplitude modulation on a 600 kilocycle carrier.

The horizontal scanning is electronic at both scanner and recorder. Standard cathode ray tubes are used and the rate is 240 lines per second. Vertical scanning is provided by the continuous motion of the subject and the copy.

High speed printing of the image generated on the cathode ray tube at the receiver is accomplished by a continuous xerographic printer and processer which occupies the lower section of the receiving unit.

One of the drawbacks of this equipment—from a commercial standpoint—is that it requires 100 kc bandwidth, at the speed it now operates. But Navy engineers point out that at least 20 remote control enterprises, authorized by FCC, use kilocycles in excess of this bandwidth. This system takes radio or wire transmission facilities with speed, or bandwidth capabilities approximately 1/20 of that required for television.

SYSTEM TRAINING

SYSTEMS ENGINEERING has become a familiar expression in the aircraft and electronics industries. Now the University of Pennsylvania will offer a graduate degree with a major in systems engineering at their Moore School of Electrical Engineering. At the start, the new curriculum is being geared primarily to the expanding military and civilian developments in electronics and science. Scientists of the Radio Corporation of America worked with Pennsylvania officials in establishing the new training program.

Educators think they've enlarged the usual connotation applied to this subject. They say the idea that systems engineering is the combination and coordination of a number of available items into a single system is too limited. The new concept includes the application of principles of research and theory to find the best approach to complicated problems.

Minimum qualifications for the two-year course are a bachelor degree in either electrical engineering or physics. A master's degree or its equivalent is preferred. Students will be expected to be adept in the fields of physics, mechanics, mathematics, circuit theory and electronics.

Most likely prospects for the course are engineers currently employed by companies engaged in communication, guided missile or aircraft work.

1954 AUTO

HUDSON SUPER JET typifies this auto maker's approach to low-priced market. 1954 model has new low-silhouette and one piece front and rear windows.

HUDSON HORNET retains "step-down" interiors but external styling is new. Emphasis is on flowing lines in both front and rear.

DODGE ROYAL represents a new deluxe series with special interiors and new body colors. Other 1954 models are longer and spear-like molding makes them look lower.

IN DETROIT EACH YEAR, autumn is the season for anxious waiting as the automobile industry, company by company, unveils new models. This year the rest of the country has joined in the anxiety. How well 1954 auto designs are accepted by consumers may dictate what kind of economic year is ahead.

When 1953 models appeared, company presidents confidently predicted heavy early sales, but tough selling before the year was finished. Both predictions have been borne out. As the year comes to an end, auto dealers are finding it almost impossible to move their monthly quotas of cars. They're resorting to fabulous trade-ins, gimmicked promotions, and hard-selling of design features.

Naturally the sales picture is reflected in new cars. Automobile makers always boast that customer's opinions appear in new cars faster than in any other product. They say they bend over backwards catering to public tastes.

Last month the 1954 parade started. Hudson led off with a newly styled Jet (their low-priced car) and Hornet (medium-priced vehicle). By the first week in November, Chrysler Corporation had finished showing off the new Plymouth, Dodge, De Soto and Chrysler.

From this preview, observers have drawn a pretty good picture of what to expect when the rest of the industry unfolds its plans. For 1954: wider acceptance of the "power" accessories, brighter external colors and deluxe interiors to woo female customers, and even more horsepower.

The new Plymouth is a typical example. Last year, Chrysler maintained that a low priced car didn't need an automatic transmission, power steering, fancy interiors, and other accessories found on more expensive autos. But this year things are different. Now Chrysler says accessories are important. So the 1954 Plymouth will offer Hydrive—no shift unit made up of combination torque converter and three-speed transmission (*Product Engineering*, June 1953, p. 156)—a link type hydraulic power steering, and the

PARADE

strongest emphasis on interiors in Plymouth's history.

From a styling standpoint, the new Plymouth is longer, and the stepped luggage compartment changes the traditional outline completely.

Dodge—completely new last year—stresses styling changes this year. More and brighter colors for exteriors, specially tailored interiors and minor sheet metal changes characterize the 1954 model. In addition, output of the Red Ram V-8 engine introduced in 1953 at 140 hp, has been stepped up to 150 hp.

To indicate the emphasis Dodge places on color and interiors, they've even announced an entire new line, the Dodge Royal, whose stress is on that phase. Only difference between Coronet and Royal models is additional chrome on the Royal, and specialized interiors that include leather and other extra-cost fabrics.

De Soto's Firedome Eight engine will be rated at 170 hp this year (1953 rating—160 hp). But the major change is exterior styling. The new De Soto looks longer, wider and lower. Responsible for the new look are a "floating" grille, "hooded" head lamps, contoured bumpers and fender, and the sill and belt moldings.

All Chrysler Corporation cars, except Plymouth, will offer—as optional equipment—the new Power-Flite fully automatic transmission. This year, these cars will offer models without clutch pedals for the first time.

With the announcement of the 1954 Chrysler line comes the first significant move in Motordom's "Horsepower Sweepstakes". The Firepower V-8 engine, rated last year at 180 hp, has been boosted to 235 hp for the New Yorker Deluxe, Custom and Crown Imperial models. The New Yorker has been raised to 195 hp; the Windsor Deluxe stays at 119. To get the extra 55 hp out of their V-8 engine, Chrysler has adopted a four-barrel carburetor, larger intake and exhaust ports and manifolds, and a dual exhaust system to reduce back pressure. The cars retain traditional Chrysler lines. Newly designed grilles and trim accentuate the sweeping effect.

PLYMOUTH BELVEDERE is longer and lower than 1953 models. For the first time the company offers automatic transmissions, power steering and fancy interiors.

DESOTO FIRE DOME EIGHT has undergone a major styling change. It is longer, lower, and wider—an effect increased by the contour fenders and chrome moldings.

LAVISH INSIDE STYLING of this 1954 De Soto illustrates the current emphasis on interiors. Note new bolstered seat design and pleated seat backs.

Just Look at the Threads

All you need do is take a close look at the threads on a Bethlehem Bolt, and you'll see why these bolts are so good to use. Bethlehem Bolts have threads which are clean and smooth-fitting. They're the kind you can count on for quick, accurate assembly.

And good threads are not the only advantage of Bethlehem Bolts. They have straight shanks, and smooth-sided heads which are easy for the wrench to grip. What's more, Bethlehem Bolts come in a wide size range, covering virtually every requirement.

If you use bolts in your business—no matter what the type, size or quantity—we're at your service.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

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BETHLEHEM STEEL

Bethlehem supplies every type of Fastener

Design Charts for Rectangular Wire Helical Springs

VICTOR TATARINOV
Pilsen, Czechoslovakia

Selecting the size of spring wire on the basis of maximum working load P_2, initial steady load P_1, working deflection f, outside diameter D, and height L, in the preloading position represents many difficulties. However, a graphical solution can be developed to remove some of these difficulties.

The fundamental stress and deflection formulas are:

$$\tau P_2 = \frac{2\alpha\, tb^2 T}{(D-b)\,\phi} \tag{1}$$

and

$$P_2 - P_1 = \frac{4G\,\gamma\, tb^3 f}{\pi n\,(D-b)^3} \tag{2}$$

Eqs (1) and (2) can be used when b is less than t. With b greater than t, the equations should be modified to establish the minimum value of cross section moment of inertia. Then,

$$\tau P_2 = \frac{2\,\alpha\, bt^2 T}{D-b} \text{ or, in certain cases } \tau P_2 = \frac{2\,\beta\, tb^2 T}{(D-b)\,\phi} \tag{3}$$

and

$$P_2 - P_1 = \frac{4G\,\gamma\, bt^3 f}{\pi n(D-b)^3} \tag{4}$$

To simplify the solution of Eqs (3) and (4), graphs can be constructed to estimate ratio D/b and b/t on the basis of D, P_1, P_2, f and L_1 given. The chart in Fig. 3 is constructed for values of A and B, which represent the stress and deflection equations modified as follows:
If $b<t$,

$$A = \frac{D^2 T}{\tau P_2} = \frac{(D/b)\,(D/t)\,(D/b-1)\phi}{2\alpha};$$

but if $b>t$

$$A = \frac{(D/t)^2\,(D/b-1)}{2\alpha} \text{ or } A = \frac{(D/b\,(D/t)(D/t-1)\phi}{2\beta}$$

For $b<t$, the deflection equation would then be:

$$B = \left(\frac{P_2 - P_1}{D^3}\right)\left(\frac{L_1 - 1.05f - (m-0.5)t}{f}\right) = \frac{1{,}463\times 10^4\gamma}{(D/t)^2\,(D/b-1)^2}$$

With $b>t$

$$B = \frac{1{,}463\times 10^4\,\gamma}{(D/t)^2\,(b/t)^2\,(D/b-1)^3}$$

This chart consists of two sets of sloping lines designating ratio D/b corresponding to values of A and B that are represented by right-hand and left-hand vertical scales, respectively. To determine D/b and b/t, find the points where the horizontal lines, traced from scales B and A, intersect corresponding sloping lines. Projecting these points to the bottom scale will give a suitable value of b/t.

Table I—Notation

P_1 — initial steady load on the spring, lb
P_2 — maximum working load on the spring, lb
τ — factor of safety selected from Table II
P_3 — breaking load exerted on the spring, lb
T — ultimate strength of spring material in torsion, psi (see Fig. 1)
G — outside diameter of spring coils, in.
t — dimension along the spring axis, in.
b — dimension perpendicular to the spring axis, in.
ϕ — stress correction factor equal to:

$$\frac{C-1.25}{C-2} + \frac{0.615}{C-1}, \text{ where } C = \frac{D}{b}.$$

f — deflection of spring from the position of its preloading (under load P_1) to its maximum working compression (under load P_2), in.
α, β and γ — coefficients of polar moments of inertia given by Fig. 2 for different ratios b/t or t/b.
L_1 — length or height of the spring preloaded, in.
n — number of active coils
m — number of inactive, end coils.

Thus, with n less than 5, $m = 1.5$; with n from 5 to 10, $m = 2$, with n equal to or greater than 10, $m = 2.5$. Number of active coils is given by:

$$n = \frac{L_1 - 1.05f - (m-0.5)t}{t}$$

Table II—Safety Factor Values

Types of Duty	
Shock absorbers, railway car springs etc	= 2.5
Special light design for shock absorbers	= 1.7
Springs for safety valves and other purposes, where reliability, permanency and accuracy are required	= 3
Springs for metal- and wood-working machinery required to operate under steady loads, without shocks	= 3.5
Springs for metal- and wood-working machinery with moderate shocks	= 4

For accurate results, it should be noted that the rectangular spring wire changes its form after coiling and becomes trapezoidal in section with the larger dimension t_2 on the inside. The value of t_2 is obtained from the formula: $t_2 = 0.48 \times t \times (2D - b)/(D - b)$, where t is the original mean width.
The smaller side of the trapezoid is expressed by: $t_1 = 2t - t_2$. When calculating deflections in springs of rectangular or square material it will be necessary to consider deformation of the original cross section and to introduce reasonable alterations of the solid height due to an increased dimension on the inner side. To design an economical spring it will be necessary to use bars of trapezoidal cross-section, the larger side t_2 being on the outside. Then,

$$t_2 = 2t - 2.09t\left(\frac{D-b}{2D-b}\right)$$

HOW TO OPEN THE DOOR TO PRODUCTION ECONOMY

New design approach explores production economies with plastics

A fresh approach to cost reduction, reported in a new Monsanto management study, lies in *designing* for production economy—with plastics. Thanks to this new trend in design thinking, manufacturers in many product fields are now cutting production costs by as much as 50 per cent.

Faster cycles . . . elimination of machining, painting, assembly and other finishing operations—made possible by plastics—are now prime considerations right at the conception of the product.

For the full story of how manufacturers are cutting costs with the new approach to design problems, send for your free copy of Monsanto's new management report. Just use the coupon below. Also—if you would like individual assistance with your materials problem, call on the Monsanto Technical Council—a board of experts in plastics, who will be glad to advise you on any questions related to plastics.

FREE—Send for your product design report today. Mail the coupon below.

MONSANTO CHEMICAL COMPANY
Plastics Division, Room 2135 Springfield 2, Mass.
Please send me your report on the new approach to product design.

Name & Title _____

Company _____

Address _____

City, Zone, State _____

MONSANTO

SERVING INDUSTRY...WHICH SERVES MANKIND

Design Charts for Rectangular Wire Helical Springs (continued)

EXAMPLE 1. A compression spring suitable for a shock absorber is to be designed using 0.55 carbon steel. Values specified are: Steady initial load $P_1 = 2{,}500$ lb, maximum working load $P_2 = 12{,}500$ lb; $\tau = 2.5$.

Outside diameter, $D = 10$ in., $f = 5$ in., and $L_1 = 32$ inches. Assuming the smallest dimension of the rectangular bar $t = 1$ in., from the curve in Fig. 1 $T = 157{,}000$ psi.

$$A = \frac{D^2T}{\tau P_2} = \frac{10^2 \times 157{,}000}{2.5 \times 12{,}500} = 500$$

$$B = \left(\frac{P_2 - P_1}{D^2}\right)\left(\frac{L_1 - 1.05f - (m - 0.5)t}{f}\right) =$$

$$\left(\frac{10{,}000}{100}\right)\left(\frac{32 - 5.25 - 2}{5}\right) = 497$$

Selecting $D/b = 3.5$, lines I and II are drawn from $A = 500$ and $B = 497$ to the sloping lines corresponding to this value of D/b. Projecting these lines (I and II) to the bottom scale gives $b/t = 2.5$. Then

$$b = D/3.5 = 2.86 \text{ in.}$$

$t = 1.144$ and $m = 2.5$ (Table I)

Number of active coils, $n =$

$$\frac{32 - 1.05 \times 5 - 2 \times 1.145}{1.145} = 21.5.$$

Original dimensions of spring material are:

$$t_2 = 2t - 2.09\,\frac{D - b}{2D - b} = 1.42 \text{ in.}$$

$$t_1 = 2t - t_2 = 0.87 \text{ in.}$$

Free length of the spring

$$L_0 = L_1 + \frac{P_1}{P_2 - P_1} \times f = 32\left(\frac{2{,}500}{10{,}000}\right)(5) = 33.25 \text{ in.}$$

Weight of spring $= 0.283\pi(b)(t)(D-b)\ (m + n)$ $= 486$ pounds. A compression spring coiled of round bar designed on basis of above values specified will have $d = 1.83$ in., $n = 15$, $L_1 = 37.25$ in. against 32 in. specified. Weight of spring $= 322$ pounds.

EXAMPLE 2. Determine maximum force acting on 6 in. spring made of 1 in. square carbon steel bar. In the chart find the points of intersection of the vertical line traced from the point of the bottom scale designating $b/t = 1$ with sloping lines marked by $D/b = 6$ (See Line III). These points indicate $A = 560$ and $B = 440$, Lines IV and V.

Then

$$\tau P_2 = \frac{D^2T}{A} = \frac{36 \times 159{,}000}{560} = 10{,}200 \text{ pounds.}$$

With $\tau = 3$, $P_2 = 3{,}400$ pounds.

Selecting $P_1 = 0.15$, $P_2 = 510$ lb and working deflection f = 4 in., the following equation can be written:

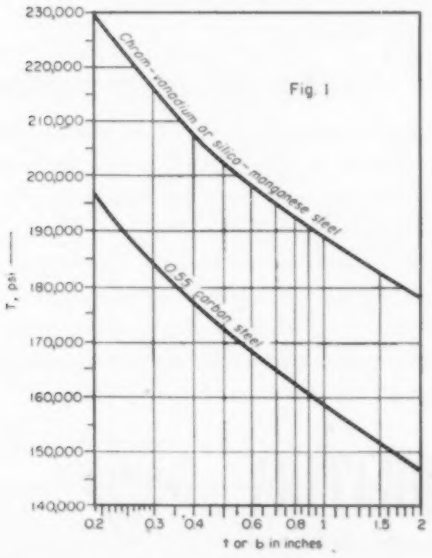
$$\frac{P_2 - P_1}{D^2} \times \frac{L_1 - 1.05f - (m - 0.5)t}{f} = 440.$$

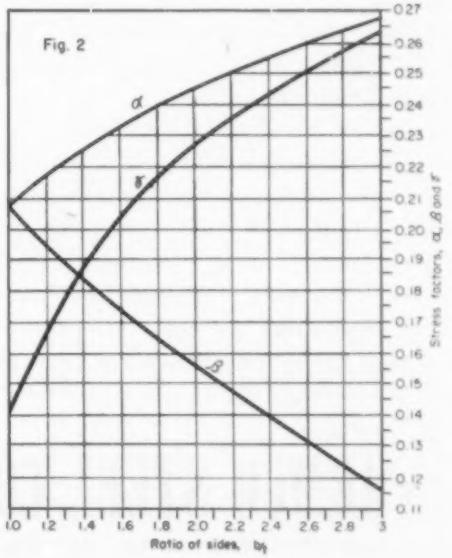
$$L_1 = 4.2 + 2 + \frac{440 \times 36 \times 4}{3{,}400 - 510} = 6.2 + 22 = 28.2 \text{ inches.}$$

Considering a trapezoidal cross-section, the larger side $t_2 = 0.48t \times \frac{2D - b}{D - b} = 1.06$ inches. Finally $L_1 = 4.2 + 2 \times \frac{1.06}{1} + \frac{22 \times 1.06}{1} = 29.62$ inches. n = 22. Weight of spring = 107 pounds.

A similar spring can be coiled of 1.03 in. round bar having $n = 18.5$ and $L_1 = 4.2 + 1.03\ (18.5 + 2.5 - 0.5) = 25.3$ inches. Weight of spring = 75.5 pounds.

(continued on page 211)





How Stainless Steel Stampings Save Money Here

Cast pilot rings (at top) for an oil-fired circulating heater warped and disintegrated—sometimes after only a few months' service. The rings wouldn't stand up at cherry-red heat, and replacements were expensive.

To increase service life of the pilot ring and reduce costly maintenance, the manufacturer replaced the castings with the stamped assembly shown below. This unit is made of 16-gage Armco 17, Type 430, stainless steel strip and ¼-inch diameter Armco 17 spacer rods. The new parts weigh about one-third as much as the castings.

Hundreds of stainless steel applications in high temperature jobs show that the manufacturer can expect to save far more in replacement expense than the additional cost of the stainless steel. Moreover, he will have a new quality sales point.

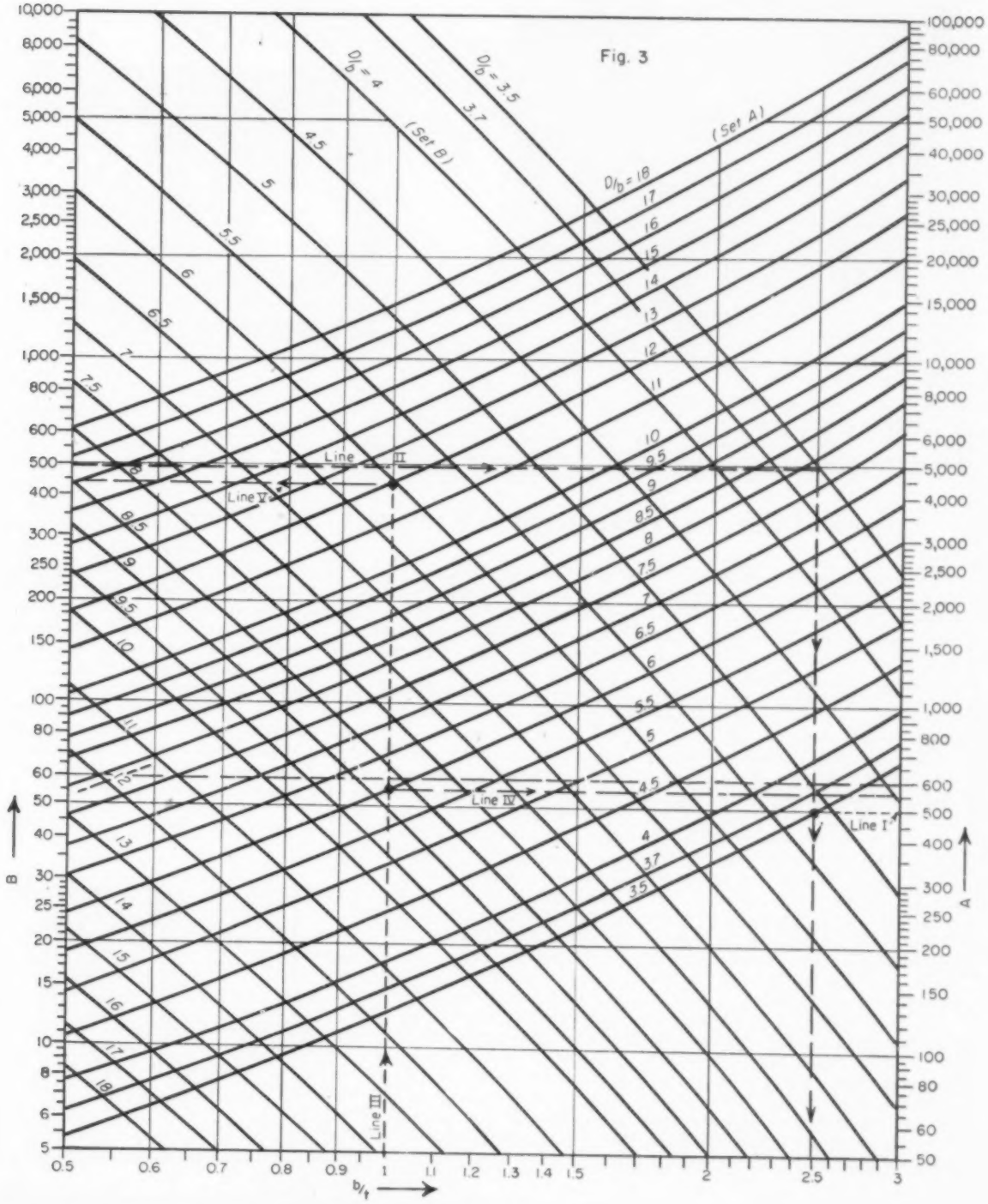
STAINLESS STEELS TO SUIT CONDITIONS

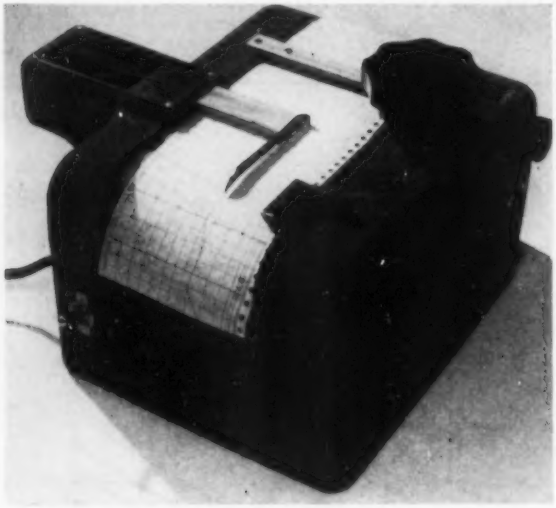
Armco 17 does well in most fiery jobs—withstands temperatures up to 1550 degrees F without destructive scaling. Yet there are numerous other stainless grades for more severe service than in this oil burner. Certain grades will resist temperatures up to 2000 degrees F. Others have especially high tensile and creep strengths at elevated temperatures. For information on how to select a stainless steel for high temperature service write for the booklet, "Armco Stainless Steels for Heat Resistance."

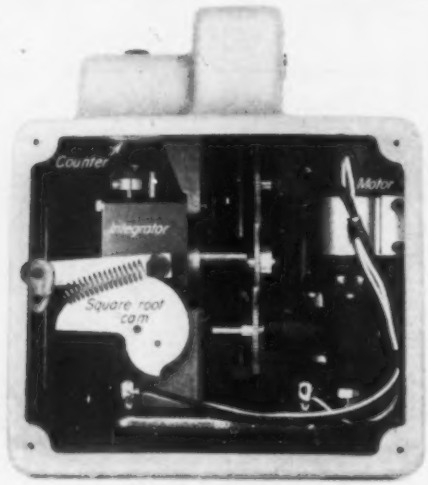
ARMCO STEEL CORPORATION

4793 CURTIS STREET • EXPORT: THE ARMCO INTERNATIONAL CORPORATION

Design Charts for Rectangular Wire Helical Springs (continued)







A CURSOR IS MADE TO FOLLOW the plotted curve by manual adjustment of the knob while the chart paper is motor driven at a controlled rate. The knob moves the cursor through a square function cam, which is partially exposed in the center section of the back view of the planimeter shown at right. The angle through which the cam is rotated in following the curve is used for displacing the ball carriage of an integrator, the disk of which is driven by the same motor as the chart drive.

Flow Chart Totalizing Without Approximation

Flowmeters as used in industry provide an output proportional to the square of the flow. This value is recorded against time on a strip chart. In order to determine the total flow for a given interval of time it is necessary to measure each ordinate of the recording, extract the square root, and integrate with respect to time.

The new square root planimeter shown provides mechanical square root extraction and integration for 3 in. strip flow charts, as obtained by conventional recorders of different makes. These strip charts, are a recording of output proportional to the square of the flow against time.

Extraction of square root accurately with any mechanical device is impossible in the vicinity of zero because the square root function has an infinite slope at the origin.

To get around this difficulty, a square function cam has been designed to drive the cursor that follows the line. The angular position of the cam is linearly proportional to flow, and this value is introduced directly to the ball carriage of the integrator. Since a square function has zero slope at the origin, no difficulty is encountered with mechanical disadvantage.

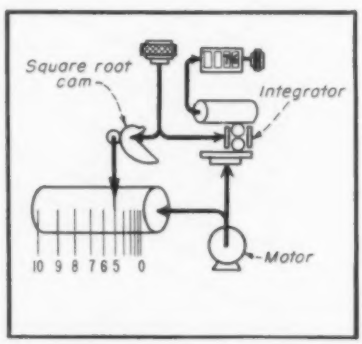
The motor driving the integrator disk for a time base is also connected to the sprocket drive for the chart. Therefore, any variation in speed of the motor does not introduce an error into the integration. The output of the integrator cylinder is then proportional to the product of the chart travel and the summation of the square roots of the instantaneous values of the ordinates of the curves being traced. This output value is recorded on a four place revolution counter which is manually resetable.

The spatial relation of the cursor tip and the sprocket drum is such that integration can start and end at the extremes of the chart paper. This is important since it is normal practice to cut off an exact 24 hour length of tape from the recorder without allowing for a leader at either end.

Features of this desk size computer are: true square root extraction, integration over a full range of flow without approximation (also available for linear integration); no leader required on chart paper, totalizing from leading to trailing edge of paper; and foot-controlled variable speed drive for survey of regions of smooth flow.

Weight of the unit is 10 pounds; approximate size is 8 x 10 x 4 inches. Power requirements: 35 watts, 115 v, a-c or d-c. The maximum traverse rate is two feet of chart length (24 hours of recording) in 15 seconds. This may be reduced by foot control for accurate integration of upsets or other flow irregularities.

Librascope, Inc.,
1607 *Flower St., Glendale, Calif.*



Symbol Stamps Save Drafting Time

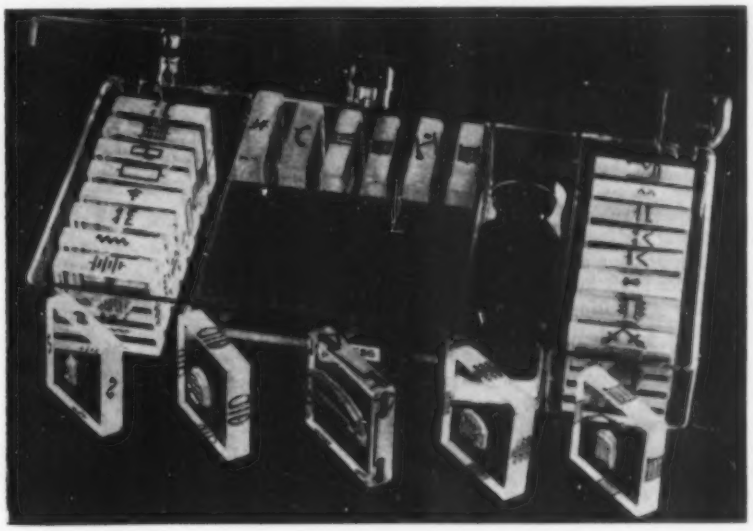
Drafting time on complicated drawings is being saved through the use of stamped symbols like those shown in the chart below. While stamped symbols of this type are not exactly new for this type of work, the fact that they are made of vinyl plastic mounted on clear acrylic plastic now simplifies the job of print alignment. In addition, the vinyl has good resistance to the inks being used, and is dimensionally stable.

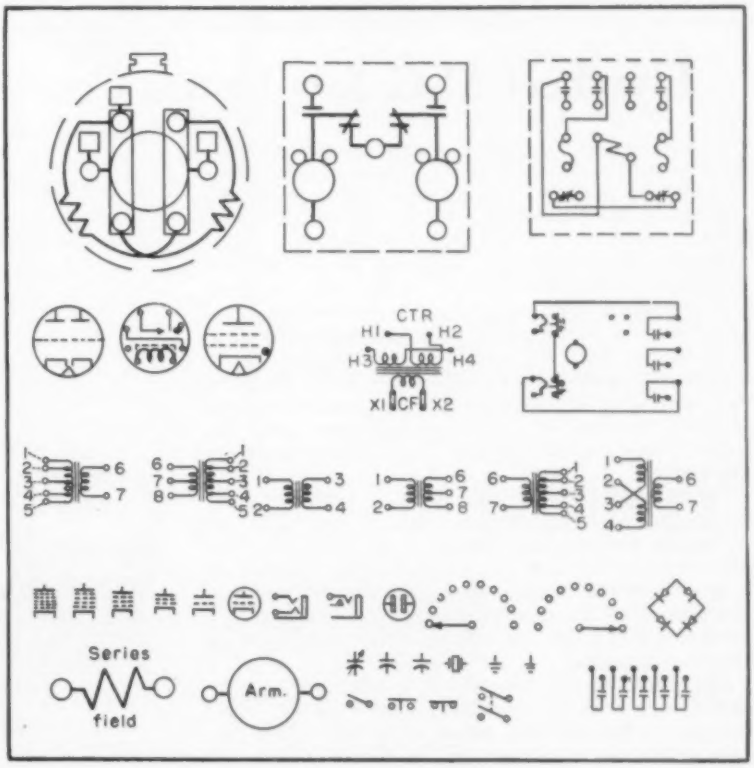
Called The Symb-O-Stamps, these stamps are claimed by the manufacturer to be 75 percent faster than any other symbol drawing method. They will print on clear acetate, which can be used as an overlay for parts of a drawing that may have to be changed, or, the entire drawing can be made on acetate. The ink will adhere to the acetate, and the acetate master will make good intermediate sepia prints.

Perhaps the most common application of the stamps has been on electrical wiring diagrams, not only for circuitry, but for illustrating such items as generators, starters, controls, circuit breakers, and other pieces of equipment. As the size of the symbols is fixed, this will result in uniformity.

Besides the standard and double size symbols, special stamps like those shown in the illustration, and a 7 x 8 in. complete circuit stamp can be made. Also, a series of note stamps that are used repeatedly may be developed. A kit of 27 stamps is shown above.

John Griffin Co., 2157 *James Ave.*, *St. Paul 5, Minn.*





CONTINUED ON PAGE 216

Miniature Speed Changers With Geared Controls

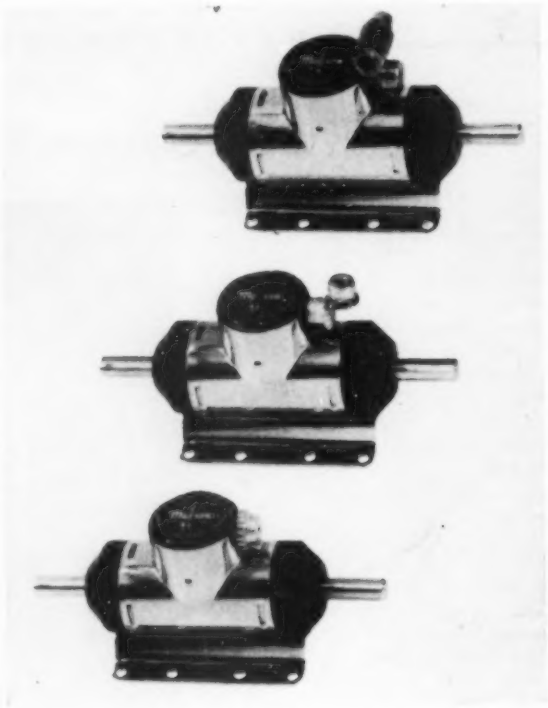
Newly redesigned series 3 variable speed changers are now available with three different types of geared controls as shown in the illustration. The output shaft speed can be infinitely varied from $\frac{1}{5}$th to 5 times the input shaft speed by rotating the speed control shaft with either spur, miter, or worm geared remote controls.

Small and lightweight, six ounces, these ready-to-use units are suited for remotely controlled applications in recorders, flow controls, regulators, scanning mechanisms, and similar devices.

The spur geared control, type 3D, may be used where the control shaft and the remote control shaft are parallel. A choice of mating spur gears permits a wide selection of control speeds.

Where the control shaft and remote control shaft must be at right angles to one another, either the miter geared control, type 3E, or the worm geared control, type 3F, is recommended. The worm geared control is said to be advantageous where a small motor is used to drive the control shaft.

The three types may be converted to flexible shaft or extended shaft control by removing the control gear. Other speed reducers rated at $\frac{1}{10}$ hp are available in 600 ratios.



Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

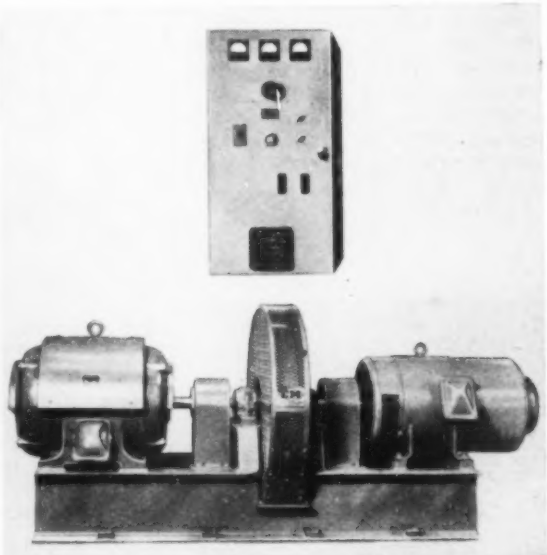
Flywheel M-G Sets Insure Continuity of Power

In order to insure continuity of power supply, flywheel motor generator sets are being used for microwave equipment used for protective relaying, supervisory control, and communication in utility, pipe line, and similar long-distance systems.

During normal operating conditions, the set operates off of the commercial power system. When there is a power system disturbance, the energy stored in the flywheel drives the generator to supply power, with a frequency tolerance down to 50 cycles, for a seven second interval. The seven second interval allows sufficient time for the automatic starting of an emergency standby generator set and automatic switching of microwave equipment from the flywheel motor-generator set power source to the emergency power source.

The automatic transfer control has a frequency relay sensitive to a 1½-2 cycle decline, which initiates starting of the standby power supply. When standby power voltage and frequency are normal, a mechanically interlocked throw-over switch connects the microwave equipment to the standby set. The microwave equipment is automatically transferred back to the motor-generator set when commercial power is restored.

Also made by this company is a magnetic amplifier control used with an adjustable speed magnetic drive. This gives a variable speed output when used with a constant speed motor. Drives are in ratings of 25 hp.



Electric Machinery Mfg. Co., 800 Central Ave., Minneapolis 13, Minn.

CONTINUED ON PAGE 216

ANOTHER NEW FAFNIR...

Ball Bearing "Economy Package"

Type PB Pressed Steel Pillow Block

The new Type PB Series Pillow Block is developed to fill a specific need for a high-quality, precision ball bearing unit at the lowest possible cost. It is made for *light duty* applications where a low-cost "packaged" unit offers definite manufacturing and servicing advantages . . . on agricultural equipment, conveyors, light-duty fans and similar types of machinery involving the transmission of power.

The Type PB Series Pillow Block opens up new opportunities to add extra product sales features and to lower maintenance costs . . . another example of the Fafnir "attitude and aptitude". Send for new, descriptive bulletin. The Fafnir Bearing Company, New Britain, Conn.

OUTSTANDING FEATURES

- Low Cost
- Precision Ball Bearing . . . Fafnir Wide Inner Ring Bearing* with Self-locking Collar and efficient Plya-Seals.
- Two-piece separable pressed-steel housing.
- Self-aligning . . . unrestricted in all directions at assembly.
- Occupies less space than other pillow blocks.
- Light weight . . . combined with ample strength.
- Only two bolt holes required in assembly.
- Ample capacity for radial, thrust or combined loads.
- Pre-lubricated with long-life grease.
- Available for shaft sizes ½" to 1¼" inclusive.

*Easiest bearing of all to install. Counterbored, eccentric, mated cam construction of collar and inner ring assures positive locking action without set screws, lock nuts or adapters.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Easily Disassembled Plug-In Circuits

Designed to permit easy visual inspection, a new line of plug-in electronic circuits is now available with a case which may be completely taken apart without tools.

The new cast-aluminum case can be easily disassembled by removing the tube shield, tube, and then unscrewing the base ring. This allows the entire assembly to be lifted apart for inspection. These plug-in circuits retain all of their shock and vibration advantages without dipping or potting in wax or resinous compounds, and all plug-ins are moisture and fungus proofed by spraying with a special dielectric compound before being cased in a corrosion-resistant container.

Typical circuits include amplifiers (pulse, DC, AF), delay circuits, multivibrators, gate circuits (diode, pulse, sine wave), phantastrons, voltage regulators, squaring circuits, "And" and "Or" circuits, delay lines, networks, crystal oscillators, and thyratron ring counters. With this method of construction, other circuits may be custom-designed.

The new plug-in case measures $4\frac{3}{16}$ in. overall in height, and $1\frac{1}{2}$ in. in diameter. Its seated height in a standard actal socket is $3\frac{5}{8}$ in., and the average weight for a circuit is $3\frac{1}{2}$ ounces. All units are supplied with octal-base headers, but any standard base from 4 to 11 pins can be supplied for special purposes.

Electronic Engineering Co. of Calif., 180 S. Alvarado St., Los Angeles 57, Calif.

Portable Non-Destructive Testing Unit

With the use of a new electronic, non-destructive testing instrument, testing with wire-like samples or the cross-sectioning of parts is eliminated. Known as the FM-100 Conductivity Meter, this instrument gives absolute conductivity measurements of non-ferrous conducting materials directly from a large dial on the front of the unit. An operator merely places the hand probe on a part and reads the dial.

The FM-100 has many uses, and for many applications, the absolute conductivity reading is all that is needed. In some cases, these readings can be used to sort mixed lots of metals.

The FM-100 can also be used for process and quality control in heat treatment, and standard comparisons must be made. Another application is controlling the purity of melt of non-ferrous metals and alloys. Small samples can be drawn, quenched, and tested with this instrument.

Magnaflux Corp., 7300 W. Lawrence Ave., Chicago 31, Ill.

CONTINUED ON PAGE 218

Customer Reports:

"We Switched to Continuous-Cast Bronzes... Rejects Now Negligible...No Field Failures"

JACUZZI BROS., INC., Richmond, Calif., had heavy losses due to rejects of pump bearings made from sand-cast bronze.

"Since switching to ASARCO Continuous-Cast Bronzes (75% Cu, 5% Sn, 20% Pb, and 83% Cu, 7% Sn, 7% Pb, 3% Zn), REJECTS ARE NEGLIGIBLE, and there have been no field failures," says Mr. R. Delahay, Jacuzzi production engineer.

Here's why ASARCO Continuous-Cast Bronzes cut rejects: porosity, dirt, hard and soft spots are non-existent; alloy constituents are uniformly distributed. Also, dimensions are held to close tolerances: +0.004" to −0.006" on O.D., and tube concentricities to within 1.5% of wall thickness. Fatigue and impact characteristics are up to 100% better than those of sand-cast or permanent mold stock; tensile and yield strengths are appreciably higher. All stock for machining is Medart-straightened.

ASARCO Continuous-Cast Bronzes are available in rods, tubes and shapes . . . in many alloys, made to your specific requirements if necessary. Lengths are *cut to the exact size you want* up to 12′ (standard) or 20′ by special arrangement.

ASARCO CONTINUOUS-CAST RODS-TUBES-SHAPES ®

West Coast Sales Agent:
KINGWELL BROS. LTD., 457 Minna Street, San Francisco, Calif.

American Smelting and Refining Company

OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

Solenoid, Pilot-Operated Valves

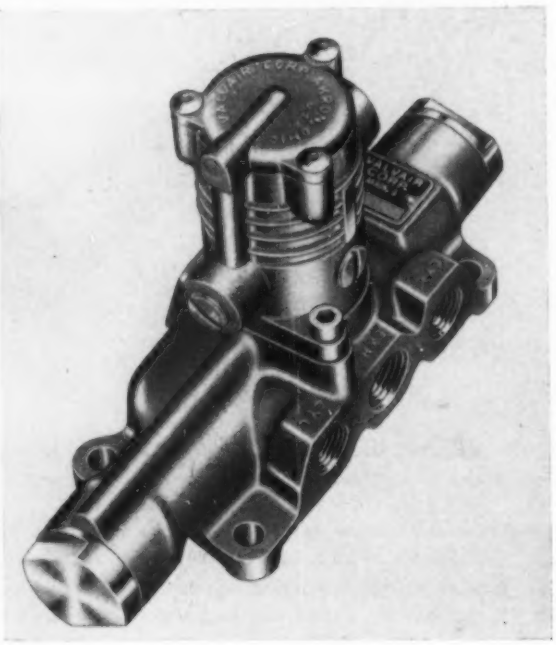
Available for air pressure operation from 35 to 150 psi, and for low pressure oil hydraulic service, are some new solenoid, pilot-operated air control valves for 3-way, 4-way, and 4-way 5-port (two pressure) application in pipe sizes of $\frac{1}{4}$ in. through one inch. All types and sizes are furnished either for foot mounting or sub-base manifold mounting, and a total of 30 new valves are included in this line to handle any type or size of requirement.

All parts are non-corrosive. The main valve body and the sub-base is cast bronze. The spool is stainless steel, hard chrome plated and polished. There is no spring in the main valve, since air from the pilot valve is used to reverse the spool in both directions. The spool is the one moving part of the main valve body, and all parts are accessible without disturbing the piping to the valve.

The pilot valve control unit is manifolded with cap screws to the main valve body. An optional manual override is available for the pilot valve, which makes operation possible when electric current is off or when cylinder control set-ups are of importance. All parts of the pilot valve are totally enclosed to give the complete unit dust-proof and splash-proof protection.

The solenoid coil is replaceable and is available in any a-c voltage and cycle, including all direct current requirements. The maximum current consumption at any voltage is 10 watts, giving cool operation and long life at operating speeds as high as 600 cycles per minute. The solenoid can be held energized for any length of time without overheating, and is applicable for constant or intermittent duty.

The $\frac{3}{8}$ in. 4-way foot mounted valve is $7\frac{3}{4}$ in. long by $4\frac{3}{4}$ in. high, and $2\frac{3}{4}$ in. wide. Direct flow through the valve has been maintained to minimize pressure drop. Valves can be mounted in any position.



Valvair Corp., Morgan Ave., Akron 11, Ohio

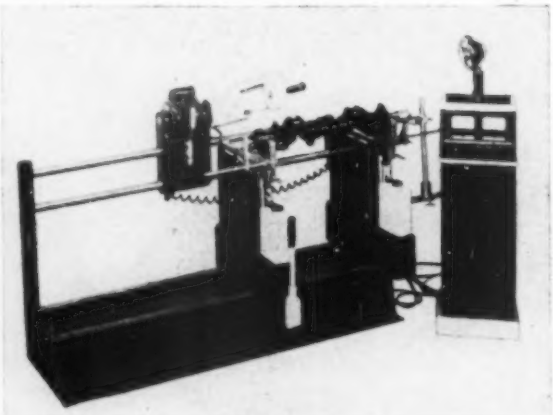
Industrial Balancer Easily Set Up

Quick set up (less than two minutes), plus wide capacity range are features of a new electronic industrial balancer used for maintenance as well as production balancing. High speed milling heads, cutters, and grinding wheels may be precision balanced to eliminate marks due to vibration. By eliminating vibration, speeds may be increased for faster cutting as well as safety for the operator.

Precision sensitivity is possible at all weights of items checked or balanced from the range of $\frac{1}{2}$ lb. to 1,000 pounds. By turning a knob, five dash pot positions allow balancing at different sensitivities to a maximum of 0.04 oz.-inches. Because of balancing at mechanical resonance, sensitivity remains the same at all weights of object being balanced. The part being balanced is brought above the resonant speed and allowed to coast freely through the balancing zone, so that the readings are not affected by the drive belt or other contacts that may introduce error.

The drive mechanism is operated by twisting a handle which is also used as a brake after the readings are observed. Setup to various lengths is done by a walking mechanism operated by a handle on a moveable stanchion.

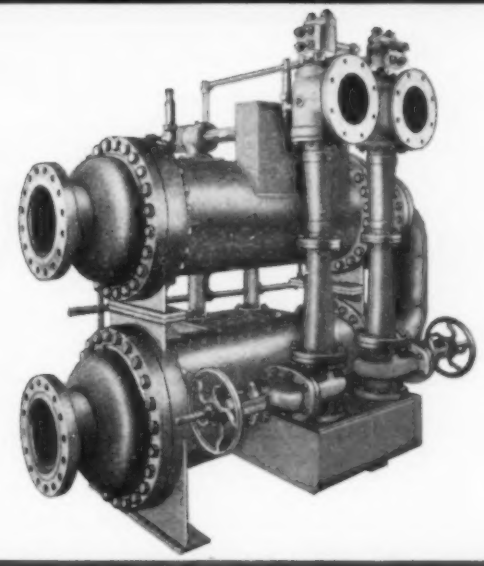
Length range is $4\frac{1}{2}$ inches to 55 inches between bearing surfaces. Diametral capacity is $\frac{1}{2}$ in. to 44 inches. Feature of the unit is its quick setup.

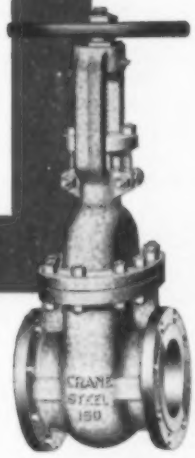


Merrill Engineering Laboratories, 1240 Lincoln St., Denver 3, Colo.

CONTINUED ON PAGE 220

HOW ALLIS-CHALMERS BUILDS A COMPACT AIR EJECTOR





Crane 150-pound Cast Steel Wedge Gate . . . An unusually rugged valve, available in carbon or alloy steels, with a variety of trim materials for oil, oil vapor, steam, water, or air. Flanged, welding or screwed ends; all sizes.

another successful product design with piping equipment by CRANE

Here is Allis-Chalmers' novel two-stage, twin element *steam jet* air ejector. It makes use of the inter condenser as the lower condenser to reduce over-all height and increase versatility in installation.

This unit is used to remove air and non-condensibles from a 74,000 sq. ft. steam surface condenser. Each stage of the ejector is valved to permit isolation for maintenance during operation. Like many another manufacturer looking to utmost dependability in product design, Allis-Chalmers chose Crane equipment for the valving procedure.

For dependable piping equipment on your product, you need only turn to the big (580 pages) Crane Catalog. Here is the world's largest selection of quality valves, fittings and specialties, with the kind of data you want—sizes, dimensions, temperature and pressure ratings, with complete information on materials and constructions. It's the Catalog that makes "Spec" writing easier—and adds value to your product design.

YOU'LL FIND IT HERE ...IN YOUR CRANE CATALOG

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

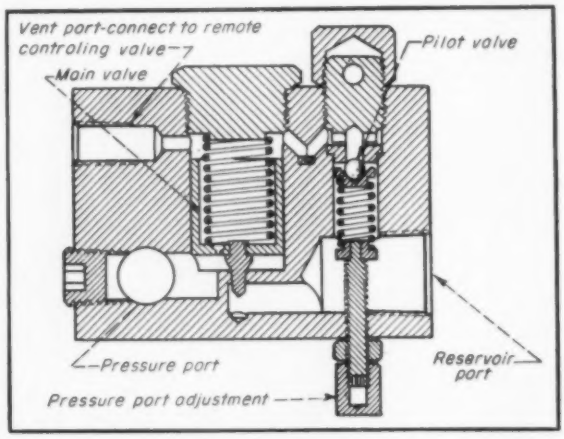
Remotely Operated Relief Valve

Remotely operated relief valves, used when it is not practical to place the relief valve in a normally accessible location or near other machine controls, have been developed in the form of a pilot-type relief valve with an internal pilot valve, and provision for connecting one or more external pilot valves. Generally, the internal pilot valve is set at the maximum rating of the pump or machine, and the external pilot valve is adjusted to suit the operation being performed.

Relief pressure is constant and not affected to any extent by flow, temperature or oil viscosity. No warm-up time is required. Cracking pressure is 90 percent or more of maximum relief pressure.

Pressure range of the ½ and ¾ in. size is from 1,000 to 3,000 psi. Capacity at 1,000 psi is 28 gpm; and at 2,000 psi is 39.5 gpm. The pressure range for the ¼ and ⅜ in. size is 50 to 1,000 psi or 500 to 4,000 psi.

Additional features of the remotely operated units: light weight and compact design for easy installation; long life; trouble-free service; and noiseless operation.



Fluid Controls, Inc., 1284 No. Center St., Mentor, Ohio

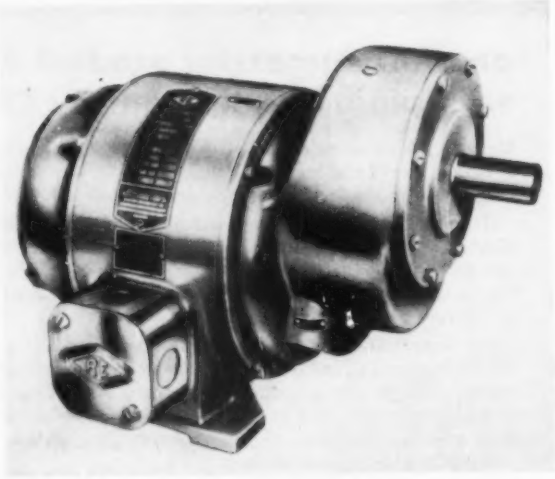
Offset-Shaft Speed Reducer Simplifies Mounting

By simply rotating the endbell, the output shaft of a new model Motoreducer can be connected to the load either above, below, right, or to the left of the drive motor. Besides eliminating the necessity of making mounting platforms, true, in-line hookups and compactness are possible when designing into the original equipment.

Mechanical features include: (1) oil bath lubrication of all gears, (2) quiet running with helical gears, and (3) transmission of lateral load stresses to the motor's base.

The new offset-shaft unit is a single reduction unit, and is available in hp ratings from ½ through 5 hp, and in output speeds from 190 through 520 rpm. Additional versatility is possible through the use of fluid-shaft, slip ring, squirrel cage and multi-speed motors.

These motors, in turn, are available with either one or two through-shaft magnetic brakes located at any point on the output or input shafts. The through-shaft permits extension of the drive shaft entirely through the brake.



Reuland Electric Co., Alhambra, Calif.

SYNCHRONOUS TIMING MOTORS with torque ratings of 40 in.-oz. at 1 rpm are available in unidirectional or reversible models in output speeds from ⅙ to 1,800 rpm, and for voltages from 6 to 550 v a-c. Features are: oil retaining disks that trap a supply of oil at all bearing surfaces and prevent leakage from the housing; 50 percent more bearing surface; and cut gears and pinions. Hagen Mfg. Co., Inc., 202 20th St., Moline, Ill.

A NEW INK which adheres to most plastics, can be applied with any ordinary rubber stamp and office type stamp pad. In addition to tenite, vinylite, kodapak, plexiglass, cellulose acetates, and other plastics, the new ink can be used to stamp rubber, neoprene, wood, leather, and lacquer coated tins to aid in the identification of all products. Available in red, blue, violet and black. Artone Color Corp., 21 W 3rd St., New York 12, N. Y.

CONTAINING NO NICKEL, cobalt, tungsten, chromium, or other critical materials, new ceramic permanent magnets are made by powder metallurgy from a mixture of barium and iron oxide, pressing or extruding the mixture in shape, and sintering in furnaces. The result is said to be a hard, brittle substance with good permanent magnet qualities when magnetized. Ferroxcube Corp. of America, 195 Marshall St., North Adams, Mass.

CONTINUED ON PAGE 222

LEAR GIVES SURE CONTROL FOR COWL FLAPS ON CONVAIR 340

To MATCH its exceptional ability to "get up and go," the versatile Convair Liner 340 needs precision control of its engine cowl flaps. Positive action and exact positioning for this important function are provided by Lear screwjacks.

Lear screwjacks form but one part of a comprehensive line of Lear electro-mechanical actuating products for aircraft use. Their compact design, light weight, high strength, and precision operation spell out the reasons for the use of Lear electro-mechanical products on almost every commercial and military aircraft flying today. Let us discuss *your* electro-mechanical problems. We will either have the answers on hand or be able to develop them quickly.

LEAR MODEL 550 SCREWJACK *(shown above)*
Combines with three similar units to complete a positive, non-reversing engine cowl flap control system for the Convair 340. The entire assembly is actuated by a common power source through a Lear system of flexible shafting, which can be utilized to transmit power to additional accessories.

EM-4

LEAR INC. GRAND RAPIDS DIVISION
110 IONIA AVE., N. W., GRAND RAPIDS 2, MICHIGAN
Executive Offices: 3171 S. Bundy Dr., Los Angeles 34, Calif.

Instrument Records Three Variables at 20 Points

Capable of recording in sequence the values of three variables at 20 different points, this new instrument will take any physical quantity for which a sensing element can provide an electrical output. Some of the variables that can be measured are: current, power, strain, humidity, liquid flow, liquid level, speed, and displacement.

The unit can be set to different combinations of manual or automatic operation. It also can be set to record from one to three variables and can be adapted to record as many as 60 variables.

The time necessary to sample and record all 60 measurements is approximately two minutes. As values being measured are printed on recorder, symbols are automatically printed to identify the variable being measured and point of meaurement.

The switching unit can be set to record the three variables at one point, and then automatically switch to next position. It can also be set to record in sequence any one of the variables at each of the 20 positions, or to record the three variables at one position. The instrument will also give time history of any one point variable.

In the electrical system of a factory, a recording can be taken of current, voltage and power input to different parts of factory for check on power demands and power factor.

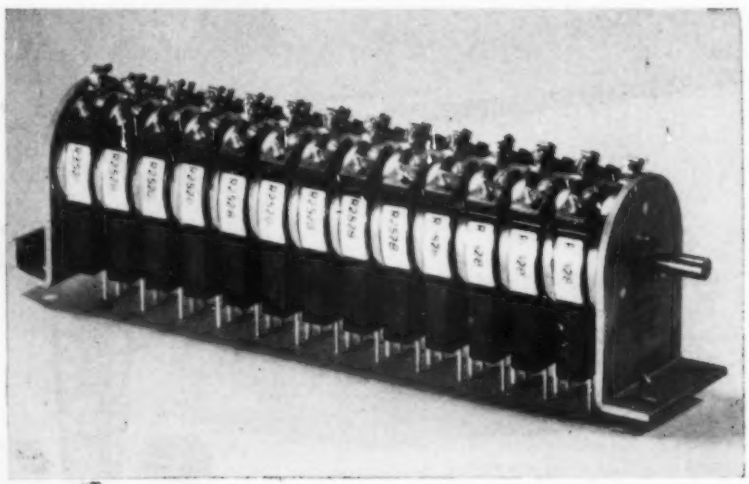
In an air conditioning system, a continuous record can also be made of the temperature, the rate of flow in ducts at twenty points, and the air temperature in enclosures into which the ducts will discharge.

Hastings Instrument Co., Hampton, Va.

Plug-In Potentiometer Simplifies Maintenance

Redesigned to incorporate a plug-in feature for aircraft equipment, the new P-746 multi-gang precision potentiometer units mount quickly and easily because only end plates are fastened. There are no wires to connect or solder, and accessible test points make for quick checking. Up to twenty units can be ganged on a single shaft for maximum rigidity. There is no radial shaft play due to couplings, since no couplings are used.

The P-746 has an overall resistance range from 680 to 115,000 ohms ± 5 percent for linear windings. Electrical function angle is 320 deg with a functional tolerance of ± 0.5 percent for linear windings and 1 percent for nonlinear windings. Electrical contact angle is 340 deg; torque is 1.5 oz-inches.



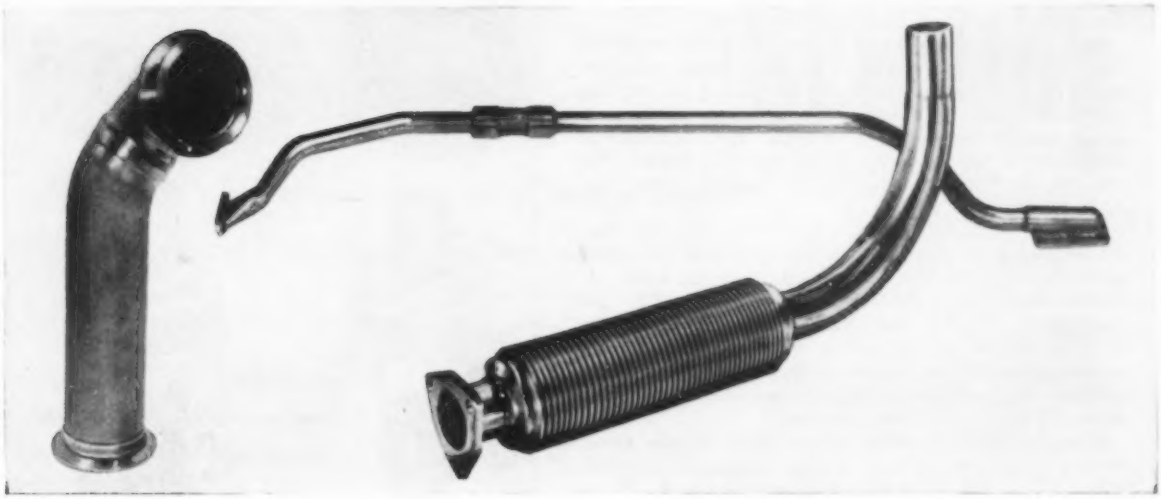
Precision mechanical tolerances are: concentricity of shaft to pilot bushing 0.001 in. FIR maximum. Radial shaft play 0.0009 in. maximum. Stainless steel shaft is centerless ground stainless steel to a diameter of 0.25 in. plus 0.0000, minus 0.0005 inch. Pilot bushing diameter is 0.5 in. plus 0 and minus 0.0005 inch. Diameter for single cups is $1\frac{3}{4}$ in. and length 0.80 inch.

Fairchild Camera & Instrument Corp., Hicksville, N. Y.

CONTINUED ON PAGE 224

WANTED

TOUGH JOBS FOR STAINLESS STEEL TUBING



Maybe you need all the inherent properties of stainless steel in tubing form, but you aren't sure how it would fabricate. What Flexonics Corp. of Maywood, Illinois does with Republic Stainless Steel Tubing may give you an idea.

Take that middle aircraft part. It's swedged, flared and bent. And those bends are tricky when you realize the small space available. That part on the left is bent and flared on one end, crimped on the other. The third part is bent, flared, cold-worked and swedged. Flexonics also spins and cold upsets Republic Stainless Steel Tubing. They get the shapes they want, plus the corrosion-resistance at high temperatures inherent in ENDURO Stainless Steel.

Perhaps Republic Stainless Steel Tubing is the answer to some of your problems. Our engineers will be glad to help you incorporate stainless steel tubing . . . or pipe . . . into either existing products or new ones. A call to your Republic representative will bring prompt action. Or write to:

STEEL AND TUBES DIVISION
REPUBLIC STEEL CORPORATION
222 EAST 131ST STREET • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

REPUBLIC STEEL

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STAINLESS STEEL TUBING AND PIPE

Quick Disconnecting Hydraulic Coupling

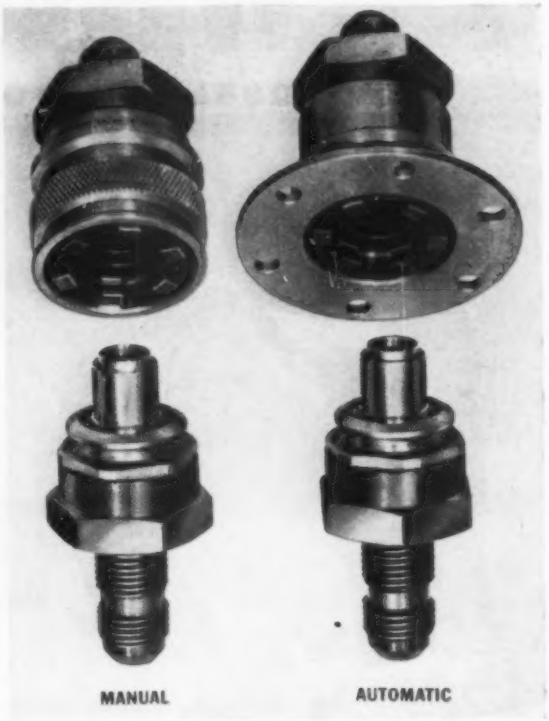
Disconnecting while under full pressure with a safe and positive action, is possible with a new hydraulic coupling having a quick-disconnect principle. Two models are available. The manually operated model can be disconnected instantly with a "pull", and connected with a "push-pull". The automatic model can be set to disconnect automatically at any desired load weight, or it can be set to disconnect at a predetermined system pressure.

Both models are adaptable in favor of either weight or flow. Where pressure drop is a problem, larger couplings can be used on smaller tube lines; such as a $\frac{3}{4}$ in. coupling can be used on a $\frac{1}{4}$ in. tube. Where weight is the main factor, smaller couplings can be used. The coupling was designed with weight-savings as an important feature. For example, the $\frac{3}{4}$ in. size is said to be 6 ounces lighter than other couplings.

This new coupling, known as the Inst-o-matic, has other advantages: It is constructed so that the valves are always open when the coupling is connected. And, the valves are always closed when the coupling is disconnected. All parts can be repaired and replaced in the field, and the socket or nipple can be used in either direction of flow without difference of operation, or without diminishing the flow. Applications are: aircraft; farm implement; automotive; railroad; and other industries.

It uses a double seal which helps make it vibration proof. For safety and to minimize leakage when disconnecting, both O-rings and flat gasket-type seals are used. When connecting, the nipple is sealed by the O-ring before the valves start to open, then sealed on the flat gasket for final seal. This gives the extra safety of a double seal.

The coupling is furnished with standard type connections: male pipe thread, female pipe thread, hose shank, AND 10050, 10056, 10057, 10058, male fairless type.



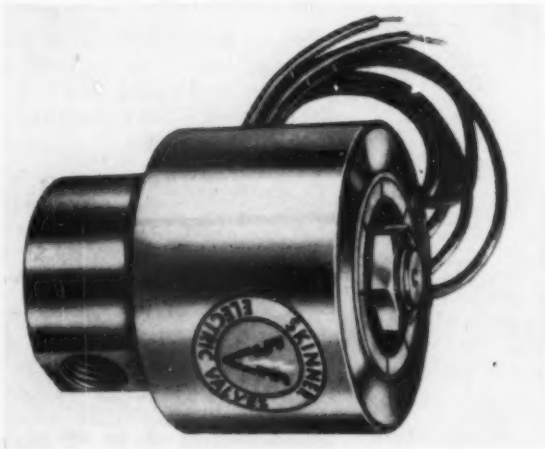
E. B. Wiggins Oil Tool Co., 3424 East Olympic Blvd., Los Angeles 23, Calif.

Cut-Off Type Valve has Positive Shut-Off

This cut-off type stainless steel solenoid valve, designed for LPG automotive fuel systems, especially trucks tractors and buses, features snap-shut action, and absolute, bubble-tight sealing.

The series V61 valve is adaptable to factory installation or fast, easy installation in the field. Rugged and compact, it has only two moving parts, and can be disassembled and serviced without removal from the line. A heavy spring return gives positive shut-off regardless of the valve's position. Operation is guaranteed under conditions of extreme vibration, high temperature, high humidity, and low voltage.

Standard models in the series are the V61-200, rated at 250 psi with a 0.136 in. orifice, and V61-300 which is rated at 300 psi with a 0.125 in. orifice. Both models are tapped for $\frac{1}{4}$ IPS pipe size, and are available for 6 or 12 v d-c operation. The size is: $2\frac{3}{4}$ in. high by $2\frac{1}{4}$ in. in dia, and weight is $1\frac{1}{2}$ pounds. The V61 valves can be easily modified to meet any special requirements and are being offered with a built-in check valve to prevent any back flow between the two tanks of a double tank system.



The Skinner Chuck Co., Electric Valve Div., New Britain, Conn.

CONTINUED ON PAGE 226

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For catalogs and bulletins, simply circle on the post card the numbers which correspond to those that accompany our editors' listings and descriptions. Our Reader Service Department will do the rest.

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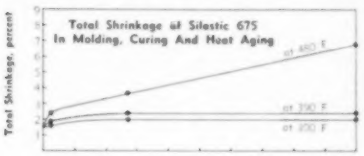
DOW CORNING

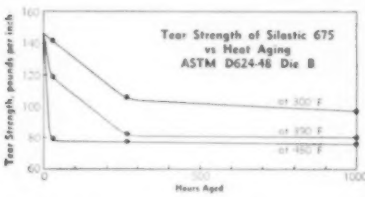
Silicone News

No. 3 of a Series • PUBLISHED BY DOW CORNING CORPORATION, MIDLAND, MICHIGAN

Remarkably Low Compression Set And Low Shrinkage Characterize New Extreme Temperature Silastic*

Silastic 675, a newly developed molding stock, has a combination of properties that is unique even among silicone rubbers. Serviceable from —100 to 500 F, Silastic 675 exhibits the lowest compression set of any extreme temperature silicone rubber. After 22 hours at 300 F, for example, compression set of this new molding stock is in the range of 15 to 20%; after 70 hours, 20 to 28%.





Silastic 675 is well suited for use in applications where low shrink in service is essential. Total shrinkage of molded test samples is below 2.5% after 1000 hours at 400 F; less than 7% after 1000 hours at 480 F. This low shrinkage characteristic also makes it possible to fabricate parts for many applications in the same molds used to form conventional organic rubber stocks.

Silastic 675 also has good dielectric properties. Dielectric strength is 550 volts per mil. Measured at 10^2 cycles, dielectric constant is 3.07 and power factor is 0.0032. After seven days at 25 C and 100 percent humidity, surface resistivity of Silastic 675 is 2.82 at 10^{13} ohms and volume resistivity is 8.58 x 10^{13} ohms.

In addition to its low set, low shrink and excellent dielectric properties, Silastic 675 contains no toxic additives. It can safely be used to fabricate parts which come in contact with cosmetics, food and pharmaceuticals.

Silastic 675 is therefore singularly well suited to the fabrication of resilient gaskets, seals, O-rings, bellows, switch boots and dielectric fittings and connectors. It is one of the most versatile silicone rubber stocks available. It also opens new markets that have been inadequately supplied with parts molded of either organic or silicone rubber stocks.

No. 22

* T. M. REG. U. S. PAT. OFF.

WORLD'S LARGEST UTILITY COMPANY SPECIFIES SILICONE (CLASS H) INSULATION FOR RELIABILITY

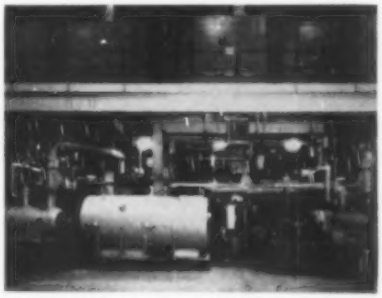
When millions of customers depend on you for 24 hour a day service, you can't take chances with your equipment. That's why the Consolidated Edison Company of New York took action when a 350 hp Class A insulated sluice pump motor failed three times in one year.

Although repeated overloading was the primary cause of failure, ambient temperatures were kept high by an enclosure built around the motor for flood protection. Failure rate was cut to once a year by rewinding with Class B insulation. The motor was then rebuilt with Class H insulation made with Dow Corning silicones. That was 9 years ago, and it is still in service.

That was Consolidated Edison's first experience with Class H insulation. Since then, many other motors have been rewound with Class H to withstand tough operating conditions. Over 79% or 71,700 out of a total of 90,500 horsepower in new motors bought for major auxiliary installations have been Class H insulated.

In buying new Class H equipment, they found that the frame size of motors rated at 200 hp or more could be reduced to such an extent that manufacturing economies often resulted in getting the added life and reliability of Class H insulation at no increase in total cost. Many solenoid coils and replacement coils for motors are also insulated with Class H materials.

Consolidated Edison has also pioneered the use of Class H insulation in sealed dry-type unit substation transformers.



They estimate that the cost of such units is more than competitive with conventional installations for power plant auxiliary supply. Convenient and safe, the Class H transformers can be located almost anywhere. And the cost of cable, switchgear, fire protection and related equipment is greatly reduced. That's why Consolidated Edison has already bought eighty-one 1250 KVA Class H transformers for unit substation work, and twelve 1000 KVA units for miscellaneous light and power.

(continued pg. 2)

(ADVERTISEMENT)

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MORE

DOW CORNING Silicone News

NEW DEVELOPMENT AND TECHNICAL DATA

For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

New pressure sensitive adhesives that stick to almost any material remain serviceable and can be applied at temperatures from —67 to 480 F. Uses include bonding silicone treated electrical insulating materials, sealing and wrapping tapes and assembly of small electronic parts prior to mechanical installation. *No. 25*

●

A reprint from Precision Metal Molding magazine describes various applications of silicone die lubricants in metal fabricating. Article includes information on effectiveness, concentrations used and methods of application. *No. 26*

●

Heat-stable, nonflammable, foamed structures can be produced from two new Dow Corning expansible resins. Such structures resist direct flame and thermal shock; undergo practically no structural or dimensional change at 700 F; show less than 0.05 percent moisture absorption after 7 days at 96 percent relative humidity. Both resins can be expanded to densities of 6 to 24 pounds per cubic foot. *No. 27*

●

Leather footwear, linemen's belts and gloves, and sporting goods, treated with Dow Corning 1109, remain water repellent for long periods of time; show greater resistance to oils and many chemicals. Silicone water repellent treatment does not impair "breathing" characteristics of leather. *No. 28*

●

Over 80 rubber companies, ready to make Silastic parts to your specification, are included in a revised listing of Silastic Fabricators. *No. 29*

●

For dependable service under the severe operating conditions frequently encountered in power distribution, welding and electronic applications, Class H transformers may be obtained from the companies included in the list of nearly 100 manufacturers of Class H Transformers. *No. 30*

●

"Tall Tales and Fabulous Facts" is a new 24-page booklet in which a parallel is drawn between the tall tales our ancestors told about such legendary characters as Paul Bunyan, Davy Crockett and Pecos Bill and some of the equally fabulous facts about Dow Corning silicone products. *No. 31*

DOW CORNING CORPORATION - Dept. RI-11
Midland, Michigan

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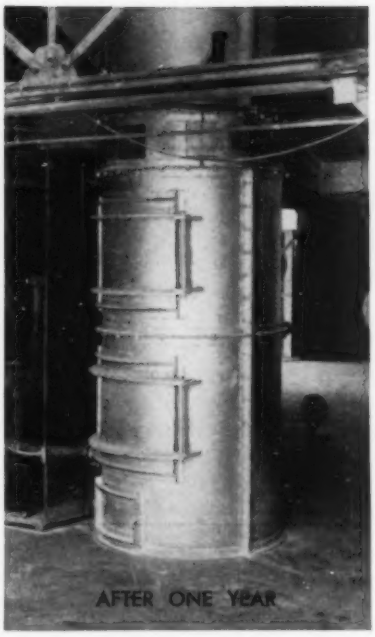
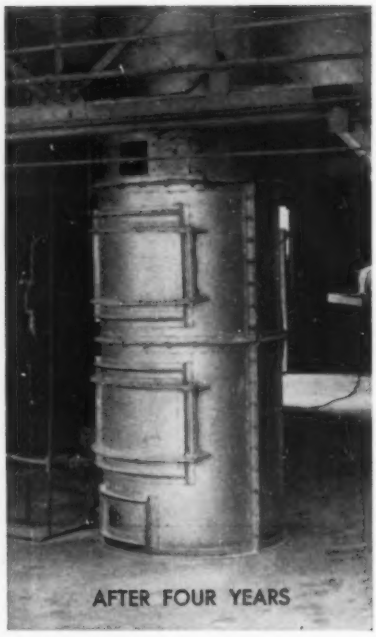
CITY _____ ZONE ___ STATE _____





Silicone Aluminum Finish On Cyclone Furnace Intact After 4 Years At Temperatures From 70 to 1400 F

In the manufacture of perlite, a lightweight plaster aggregate, Panacalite Pacific Inc., of Los Angeles expands crushed volcanic rock in a cyclone furnace. Originally the furnace stood outside, exposed to the weather. Four times a day it was charged, raising its surface temperature from 70 F to 1400 F.

Three different attempts were made to protect the furnace with aluminum pigmented organic paints. Each application failed completely in a few hours.

Then in December, 1949, the furnace and its hopper were sandblasted, treated with a phosphoric solution and painted with a silicone-aluminum finish, Dutch Boy No. 5542, formulated by the Pacific Coast Branch of the National Lead Company. Exposed to the weather for a year, including rain which fell when the surface was at peak temperature, the finish was still in excellent condition when a building was erected around the furnace and the photo at left was taken.

The second photograph was taken 3 years after the building was constructed. No repainting or other maintenance has been done to date. After 4 years service, the silicone based finish has suffered no visible deterioration or loss of film continuity. *No. 23*

CLASS H RELIABILITY *continued*

That's the attitude that a steadily increasing number of engineers and management men are taking toward Class H insulation made with Dow Corning silicones. Used to uprate equipment by as much as 50% or extend its service life more than 10 times, Class H gives maximum efficiency and maximum reliability at surprisingly little more cost than the next best class of insulation. *No. 24*

First in Silicones

DOW CORNING CORPORATION

Atlanta
Chicago
Cleveland
Dallas
Detroit
MIDLAND, MICHIGAN
Los Angeles
New York
Washington, D. C.
(SILVER SPRING, MD.)

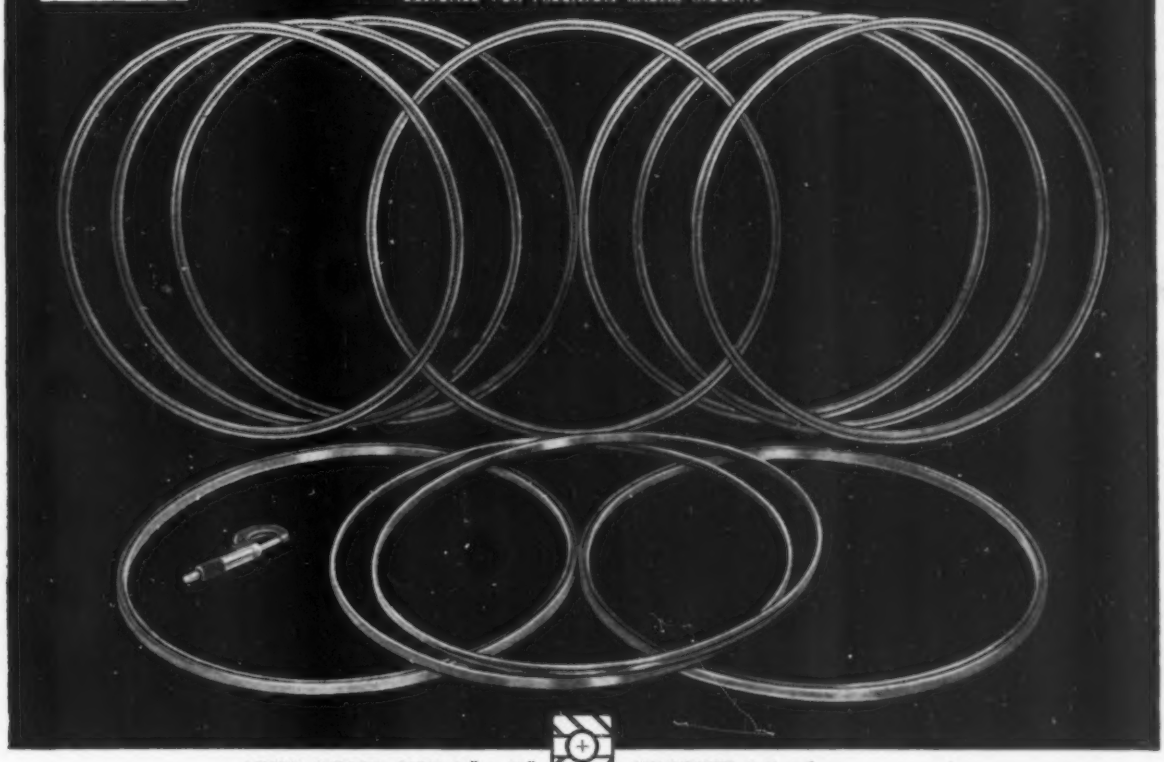
In Canada: Fiberglas Canada Ltd., Toronto
In England: Midland Silicones Ltd., London

Manufacturers of
Silicone Fluids
Silicone Abhesives
Silicone Adhesives
Silicone Release Agents
Silicone Compounds
Silicone Greases
Silicone Water Repellents
Silicone Bonding Resins
Silicone Electrical Insulating Resins
Silicone Molding Compounds
Silicone Expansible Resins
Silicone Defoamers
Silastic

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

KAYDON BALL RADIAL BEARING — 16.875" x 17.625" x 0.375"
DESIGNED FOR PRECISION RADAR MOUNTS



ACTUAL SECTION: ONLY 3/8" x 3/8"

NET WEIGHT: 2 Pounds

WORLD'S THINNEST BEARINGS

THIN AS A WEDDING RING... WITH THE PRECISION OF FINE WATCH PARTS

We specialize in large, thin-section, light weight precision bearings for Aircraft, Automotive and Industrial Equipment

Proportionately, that's an understatement! A wedding ring as big as 17.625" outside diameter would be about four times as thick as the actual 0.375" section of these thin KAYDON bearings...and even the finest watch parts, enlarged proportionately, probably would not have the precision tolerance to which these bearings are consistently finished. • These are by far the thinnest ball bearings ever made in this large diameter. KAYDON has developed the facilities and special techniques vital to such precision production.

Precision miracles in extremely large bearings of unusually thin section have become routine achievements at KAYDON. In addition to unique thinness that conserves space and weight, other outstanding features have been embodied in many special KAYDON bearings ... for instance: Flame hardened bearing races drilled, tapped and gear-cut by the KAYDON process eliminate costly auxiliary parts, help improve machine design and performance, and make possible more compact, lighter machines of greater capacity.

For unusually large, light weight, thin section bearings, contact KAYDON of Muskegon.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

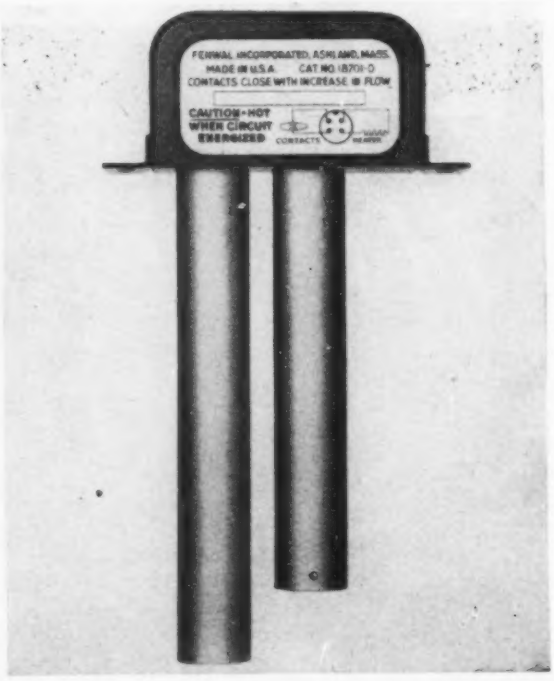
PRECISION BALL AND ROLLER BEARINGS

Sensitive Air-Flow And Liquid Level Detector

Designed to sense and respond to changes or stoppages in the flow of air, a new precision flow detecting instrument can be used as a warning device in air-cooled equipment, a ventilation control, and for similar applications where a particular flow rate must be maintained. It also may be used as a liquid-level detector or controller in storage and supply tanks. The unit responds to a change of less than 0.1 in. in liquid level.

Called the Detect-A-Flo, it operates on the principle that the amount of heat conducted away from a constant heat source varies with the rate of flow of air moving past that surface. One leg of the unit is continuously heated by a small internal heater. As the flow rate drops, the heated leg expands because less heat is conducted away. The resulting expansion is transmitted through lever action to a strut-and-electrical contact assembly in the other leg. This motion relaxes the tension in the struts and causes the contacts to move apart, thus breaking the circuit. The unit compensates for any change in the ambient temperature within its operating range of —65 to 175 F.

The maximum dimensions of the unit are 2 x 2¼ x 5¼ in.; weight is 8 ounces. The heater draws 35 watts at 28 v a-c or d-c, and a 115 v model is available. The control can handle 5 amp at 115 v a-c, or 2 amp at 28 v d-c.


FENWAL INCORPORATED, ASHLAND, MASS.
MADE IN U.S.A.
CONTACTS CLOSE WITH INCREASE IN FLOW
CAUTION - HOT WHEN CIRCUIT ENERGIZED
CONTACTS

Fenwal, Inc., 113 Pleasant St., Ashland, Mass.

Small, Accurate, Electromechanical Signal Generator

Position indicators, like the small electromechanical signal generator shown, will transform angular displacement into an electrical signal for the measurement of any mechanical variable. This electrical signal output, in conjunction with an appropriate feedback system, may be used to control industrial processes. Features of this Microsyn Position indicator are: linear output; resolution to 1/100 deg; negligible reaction torque; and sensitivity up to 7 volts/degree.

The microsyn consists of a four-pole stator and specially-shaped rotor, both of laminated high permeability magnetic steel, mounted in an aluminum housing. It can be manufactured for use as a variable inductor, a torque generator, and a stiffness motor.

Applications are for measuring: pressure, using bourdon tubes, bellows, mercury and water manometers, and flowmeters; temperature with bimetallic elements, filled thermal-systems, and bourdon tubes; Dimensions, linear and angular, such as machine tool tolerances, thickness of materials, and others. Also will measure density, humidity, viscosity, and weight.

Functionally, the device may be compared to a circular differential transformer, or to a variable reluctance balanced bridge signal generator. With this balanced bridge construction, the microsyn compensates for errors that might otherwise be introduced by mechanical, electrical and magnetic dissymetry. Because of its low torque requirement, the microsyn may be used where the primary sensing element develops a very small driving force. Because of their high sensitivity, microsyns may be used for addition, subtraction, multiplication, or division of variable mechanical inputs.

Doelcam Corp., 1400 Soldiers Field Road, Boston 35, Mass.

CONTINUED ON PAGE 228

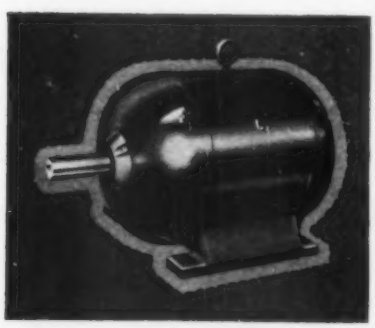
IRVINGTON
INSULATION DIGEST

Thin Slot Insulation Will Save Space in Class "A" Motors

A new type of slot insulation, specially designed to permit reduction in size of motors with Class "A" temperature ratings, will make possible the use of thinner slot cells without sacrifice of the necessary dielectric strength.

This new product of Irvington insulation research consists of a rag paper backing — carefully selected for high mechanical strength and ease of handling — bonded to a polyester film which has the exceptionally high dielectric strength of 4,000 volts per mil, as compared with an average value of 1,200 vpm for the varnished cambric used in conventional types of Class "A" slot insulation.

The dielectric strength of the polyester film (which is produced by du Pont under the trade name of Mylar) allows the use of a much thinner cross-section than would be possible with varnished cambric. Hence the over-all thickness of the slot insulation can be substantially reduced, while the desired voltage breakdown values are maintained.

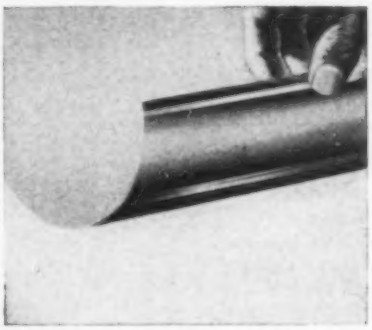


Irvington's new thin high dielectric materials meet the requirements for reduced electrical insulation thickness

New Class "B" Insulation Line Anticipates Smaller-Motor Trend

High-Dielectric Laminations Using 4,000 vpm Film Stand Higher Temperatures than NEMA Standards

Working in close cooperation with motor manufacturers, Irvington has been actively engaged for the past year in the development of a comprehensive line of the Class "B" insulation which will be required in the design of the smaller frame sizes.



First of the new types of Class "B" insulation, introduced by Irvington last year, consisted of various thicknesses of asbestos paper and polyester film, bonded in duplex and triplex combinations. The line has now been expanded to permit limitless combinations of the film and other insulating materials

The first members of this new insulation line, introduced last year by Irvington, consisted of du Pont's Mylar, a polyester film with a dielectric strength of 4,000 vpm, laminated to specially selected asbestos papers. A study of the industry's requirements, however, disclosed that laminations of Mylar with other types of insulating materials would be needed to meet design and service problems. Among the many combinations already developed are: Mylar bonded to pure asbestos, plain or saturated; Mylar bonded to asbestos in which glass fibers have been inlaid for greater mechanical strength; Mylar and Fiberglas.*

Temperature Safety Factor

While rated as Class "B" insulations, the products in this new Irvington line actually exceed the temperature limitation standards set by NEMA. Test data indicate that these laminations, bonded with adhesive developed by Irvington, will successfully withstand temperatures up to 150° C.

In addition to operating at the higher temperatures resulting from the smaller frame sizes, these new insulations have the advantage of permitting thinner insulations without sacrifice of electrical breakdown characteristics.

Their ability to withstand higher temperatures and to provide high dielectric strength in relatively thin sections will permit substantial savings in size, weight and cost in transformers and voltage regulators.

*T.M. Reg. U.S. Patent Office by Owens-Corning Fiberglas Corp.

New Adhesive for Laminated Insulation Withstands 150° C.

A new adhesive, developed by Irvington to enable the electrical industry to make full use of the advantages of the expanding line of Class "B" insulating materials, is capable of withstanding continuous operation at 150° C. This adhesive can be used for bonding Mylar — du Pont's high-dielectric polyester film — to any of the other commonly used insulating materials.

A further advantage of this adhesive is that it is not affected by any of the solvents commonly used in insulating varnishes which may be subsequently used in impregnating electrical windings.

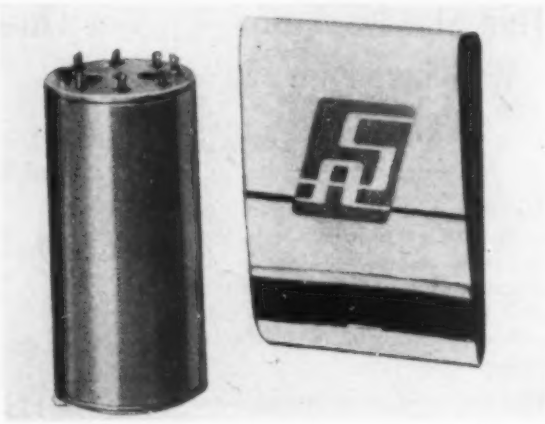
WHILE LAMINATED INSULATIONS INCORPORATING THIS NEW 4,000 VPM POLYESTER FILM ARE NOT EXPECTED TO BE AVAILABLE IN QUANTITY BEFORE THE MIDDLE OF NEXT YEAR, IRVINGTON IS INTERESTED IN WORKING OUT WITH YOU A PROGRAM THAT WILL MEET YOUR INSULATION REQUIREMENTS. FOR FURTHER INFORMATION, ADDRESS THE SALES MANAGER, COATING DIVISION, IRVINGTON VARNISH & INSULATOR, DIV. MINNESOTA MINING & MANUFACTURING CO., 10 ARGYLE TERRACE, IRVINGTON 11, NEW JERSEY.

Precision, Subminiature Rate Gyroscopes

Less than 2 in. long and 1 in. in diameter and weighing 3 ounces, this precision, subminiature rate gyroscope is hermetically sealed and is temperature compensated. The maximum linear output occurs at an input of 420 degrees per second. Resolution of the output is better than 0.05 deg. per second, and sensitivity is 14 millivolts output per degree per second input.

An important feature of this gyro is its easily adaptable design to meet most specific requirements. With an a-c output, the gyro is useful in aircraft instruments, guided missiles, fire control systems, and similar applications.

The small mass of its components makes it insensitive to shock (60G), linear acceleration (60G) and vibration (0-300cps, 5G). The unit has a high resonant frequency (85 cps) with a 0.5 damping factor. The rotor speed is 24,000 rpm requiring 6.3 volts, 400 cps, 3 watts.



Sanders Associates, Inc., 137 Canal St., Nashua, N. H.

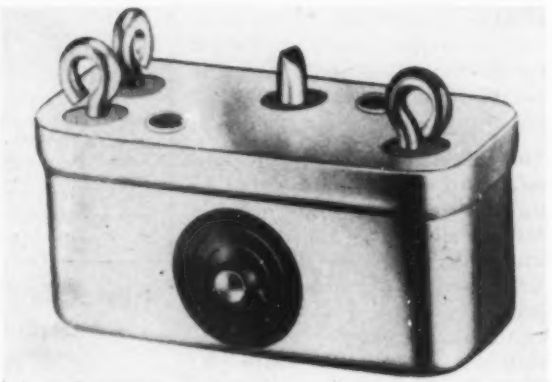
Hermetically Sealed Precision Snap Action Switch

Small, lightweight and rugged, this little hermetically sealed precision snap switch can withstand changes in pressure and temperature, exposure to high rates of acceleration, shock and vibration, and exposure to moisture, dust, fungus and a number of other corrosive elements.

It has a rapid contact traverse rate with negligible contact bounce and true snap make and break with 20 percent higher contact pressures at any point of actuation. A heavy duty beryllium copper switch blade, with silver contacts, has good electrical and thermal conductivity.

The work required to operate this switch is said to be approximately half the amount required for standard aircraft switches. Solder type terminals, handling two No. 20 stranded wires, are hermetically sealed and the hermetic enclosure withstands 100 psi internal pressure.

Resistive ratings from 0 to 50,000 ft. include 28 v d-c, 10 amp; 110 v a-c, 10 amp from 60 cycles to 400 cycles, and a minimum life of 100,000 operations at rated load.



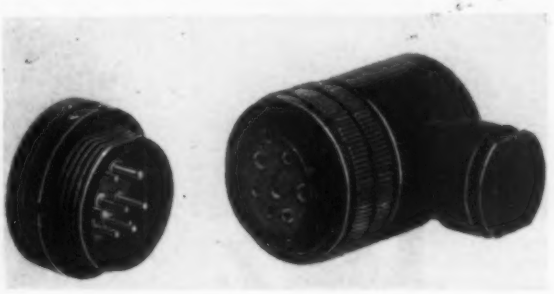
Haydon Switch Co., 232 N. Elm St., Waterbury, Conn.

Multi-Contact, Miniaturized Connectors

A new design in multi-contract miniature electrical connectors is now available for applications requiring mechanical protection with pressure-tight features. With leakage less than 1 cu in. per hr at 30 psi pressure differential, this connector is at present being used in airborne electronic equipment.

Known as the CR5-2-R, it has individual neoprene seal rings around each contact, and between the molded body and the die cast aluminum housing. The use of individual rings results in positive sealing and allows the contacts to float, eliminating alignment difficulties.

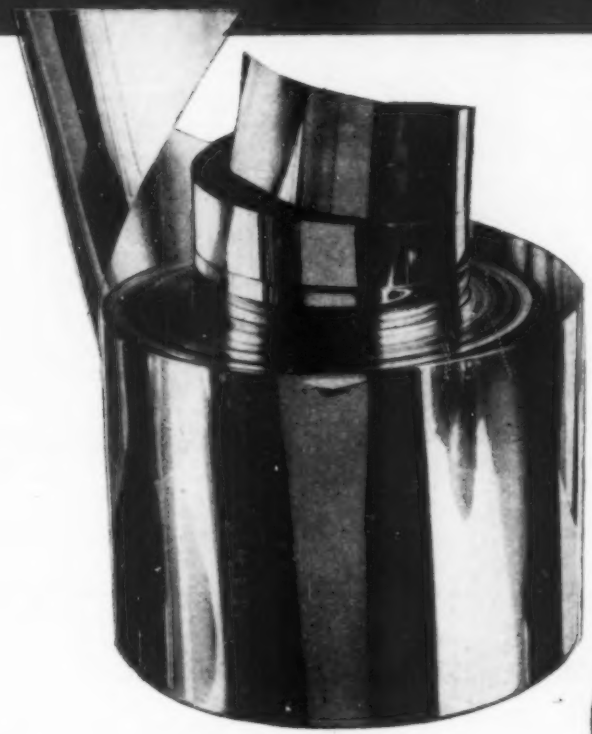
Miniaturized design of the fitting has resulted in overall dimensions of 1 in. max. dia. and $1\frac{7}{32}$ in. engaged length, with a total weight of receptacle and plug of 2 ounces.



Winchester Electronics, Inc., Glenbrook, Conn.

CONTINUED ON PAGE 230

NICKELOID METALS STARTING POINT FOR PRODUCT DESIGN



MORE THAN A METAL, IT'S A METHOD

Nickeloid Metals—brilliant pre-finished metals in sheets or coils—are ready-plated with the finest, quality plating of chromium, nickel, copper or brass. Being finished, they are ready for fabrication and assembly. They require no further finishing. They are durable, easy to fabricate. Nickeloid Metals provide a production short-cut that usually provides a basic economy in cost. Thus Nickeloid Metals are more than a raw material . . . they represent a streamlined method of production: raw material to finished part. Many operations are eliminated or short cut. Nickeloid Metals deserve further study on the part of every progressive manufacturer.

Nickeloid pre-plated finishes available in these base metals: Steel, Zinc, Brass, Copper, or Aluminum.

CREATES A NEW SALES APPEAL

The appeal to the buyer of products that have that smart, modern finish, is undeniable. The list of successful applications that have employed Nickeloid Metals to enhance eye appeal is long. From buttons to rotisseries . . . smart designers and alert manufacturers are cashing in on the basic production economy and sales appeal offered by these pre-plated metals. Our representatives, located in most principal cities, will be glad to show you samples of successful applications. They will be glad to submit working samples of metal for experimental purposes. They will be glad to give you the benefit of Nickeloid's half century of experience in the fabrication of these brilliant, gleaming, durable metals.

Quality Metals Since 1898

AMERICAN NICKELOID COMPANY

PERU 4, ILLINOIS

MILLS: PERU, ILL. and WALNUTPORT, PA.

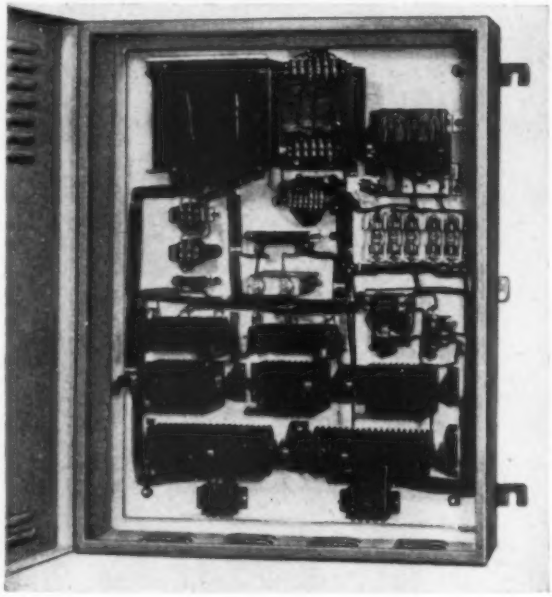
Sales offices in most principal cities

Magnetic Amplifier Adjustable Speed Drive

A magnetic amplifier adjustable speed drive without tubes is easily mounted and installed so that any machine operator can select the exact speed desired. Once the speed is set, it remains nearly constant as the load on the motor changes. Even at the low speed of 50 rpm, the speed does not drop off when load is applied, but holds about constant to loads of twice the rated motor torque.

The adjustable speed drive uses only magnetic amplifiers and selenium rectifiers. These devices have a long life, so that the drive will operate many years without attention. There are no adjustments to be made, and the drive operates properly with supply voltages ranging from 200 to 250 v with no sacrifice in life. Additional advantages of the magnetic amplifier design are: instant starting; high overload capacity; and proper operation over a wide ambient temperature range.

This new motor speed drive is said to have particular application wherever there is insufficient space on the driven machine for mounting mechanical or clutch-type drives. With this drive, a standard size motor is the only item which is mounted on the driven machine. The control enclosure can be mounted in any out-of-the-way location. The operator control station, with the start-stop buttons and the speed control knob, can be mounted in any position. Model E-1 includes a standard 230 v d-c motor with a speed range from 49 to 2,450 rpm (50L;) and is rated at ¾ hp at maximum speed. The controls are constructed according to Machine Tool Electrical Standards.



Franklin Control Corp., 1975 S. Allis St., Milwaukee 7, Wisc.

Faster Application with Spin-On Locknut

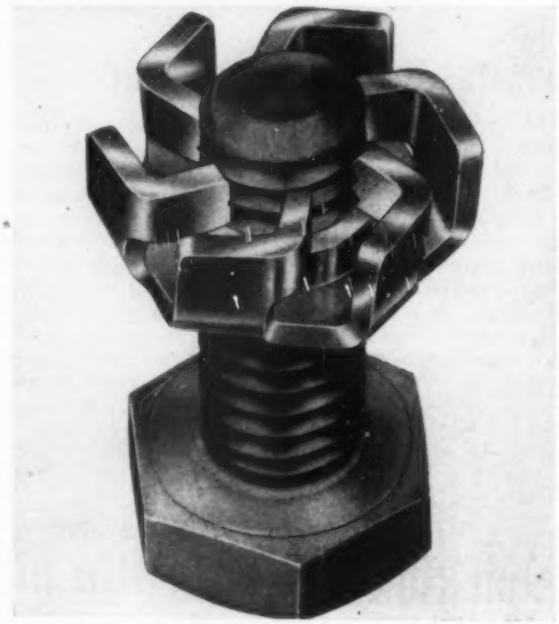
Called the "spin-down" locknut, this new locknut applies a permanent vibration-proof grip only after the nut actually contacts the work. This feature, according to the manufacturer, will increase assembly speed of automotive and industrial equipment as well as home appliances.

Formed and threaded from a single piece of high carbon steel, the locknut is heat treated after fabrication. Unlike friction type locknuts, the new nut is actually finger-free until contact with the work is made. According to the manufacturer, this "spin-down" action makes for faster application and easier handling. At the point of contact with the work, a ¼ turn takes up all play. As the nut is drawn tight, six threaded tines bite into the bolt in a "shrinking" action, caused by the concave base design. As the nut is drawn tight, the base flattens, forcing the six buttress-tines into the bolt thread.

The new locknut is said to be approximately ⅓ lighter than common hexnuts and as it is the same shape as the hexnut, ordinary six-sided socket or box wrench or power tool may be used for its application. The locknut is also unaffected by water, oil or heat up to 550 F.

The locknut is available in no. 8-10 and ¼ in. sizes in both National Fine and National Coarse threads. As shown in the illustration, the extruded base and the six buttress tines of the nut are threaded.

Thompson-Bremer and Co., 520 North Dearborn St., Chicago 11, Ill.



CONTINUED ON PAGE 232

Polaroid's "picture-in-a-minute" camera depends on BRASS

Snap the shutter on the famed Polaroid *Land* camera and a minute later you can have the processed, finished print.

When the Polaroid camera goes into action, a lot of precision-made brass parts go along with it. Each is of the composition, form, temper and finish most suitable for the purpose. Each contributes its share to a longer service life because of its durability, and its resistance to wear, fatigue and corrosion.

Little wonder that so many instrument makers depend on Brass... with so much of it from the mills of The American Brass Company. 6388

THE AMERICAN BRASS COMPANY
General Offices, Waterbury, Conn.
In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

MAKERS OF

ANACONDA®
COPPER, BRASS & BRONZE

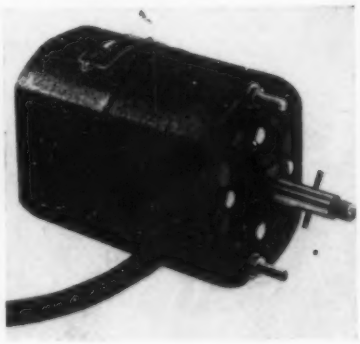
Small, High Speed, Electric Motors

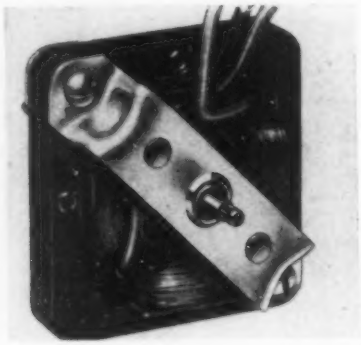
Known as the type 2-pole reversible motor, the motor at right can be wound for 6, 12, and 24 volt operation, and because of the low inertia rotor, it reverses instantaneously. The motor is protected against corrosion and uses self-aligning bearings which can be lubricated for low temperature as well as high temperature applications.

The stator is $2\frac{1}{8}$ in. square, and the overall height, over the bearing brackets with $\frac{3}{8}$ in. lamination height, is $1\frac{15}{32}$ inches. The lamination height can be varied from $\frac{3}{8}$ to $\frac{3}{4}$ in. depending upon the application, and the shaft extension can be varied. The standard shaft diameter is $\frac{3}{32}$ inch. Lead lengths can also be varied to suit the application.

When operated on twenty-four volt with an 80 MFD condenser and a stack height of $\frac{3}{8}$ in., the motor will develop $2\frac{1}{2}$ in.-ounces torque for intermittent operation. Another feature is that the motor can be switched with a single pole double throw switch.

The motor shown at left is the type 300 universal motor. It can be series





wound for speed ranges from 4000 to 15,000 rpm, and will develop at the above speeds on continuous duty 1/15 horse power, and for intermittent duty $\frac{1}{8}$ horse power. It can be wound for voltages from 6 volts to 220 volts. It can also be wound for d-c operation from 6 to 115 volts at speeds of 1200 to 7000 rpm developing 1/20 hp on continuous duty and $\frac{1}{12}$ hp on intermittent duty. The motor can be constructed with steel or die cast housings, ventilated or totally enclosed and with self-aligning bearings or ball bearings. The motor can be furnished with either a $\frac{1}{4}$ in. diameter or $\frac{5}{16}$ in. diameter shaft. The rotation can be made clockwise, counterclockwise, or reversible.

The overall dimensions are approximately $2\frac{5}{8}\frac{1}{4}$ by $4\frac{7}{16}$ inches. The overall length can be varied to suit the requirements or varied according to the height of lamination required.

The Loyd Scruggs Co.,
1002 N. 6th St., St. Louis 1, Mo.

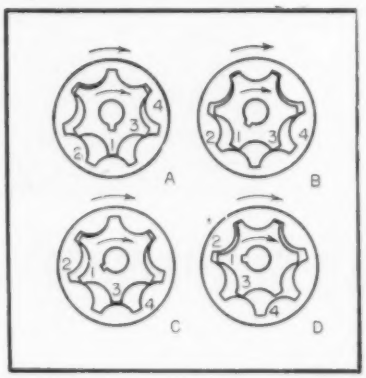
Hermetically Sealed Refrigerant Pump

This hermetically sealed pump was designed to handle the Freon refrigerants in their liquid state, and is being applied to many refrigeration recirculating systems to increase efficiency and simplify controls. It is effective on low temperature and ultra-low temperature Freon refrigeration systems.

The pump is of the Gerotor design, which has the characteristic of pumping a boiling liquid and purging itself of entrained gas. The positive displacement design permits two or more pumps to be operated in parallel.

The gerotor mechanism consists of a pair of gear-shaped elements, one within the other, having several unique features. The tooth form of the inner gerotor is generated from the tooth form of the outer gerotor so that each tooth of the inner gerotor is in sliding contact with the outer gerotor at all times.

The pump includes an oil still which serves a dual purpose of cooling the pump motor and returning oil to the compressor or compressors.



The oil is returned to the compressor or compressors by bleeding a small part of the liquid from the pump discharge into the annular space around the motor. The liquid is then vaporized to Freon gas and liquid oil. Both of these are carried out of the oil still outlet connection in the bottom of the housing to the compressor suction line. The flow of refrigerant for this oil distilling circuit may be controlled with a small thermal expansion valve.

Eight sizes are available ranging from 4 to 40 gpm against heads up to 50 psi with motors from $\frac{3}{4}$ to 3 hp.

Hetron, Inc., 333 Eberts Lane, York, Pa.

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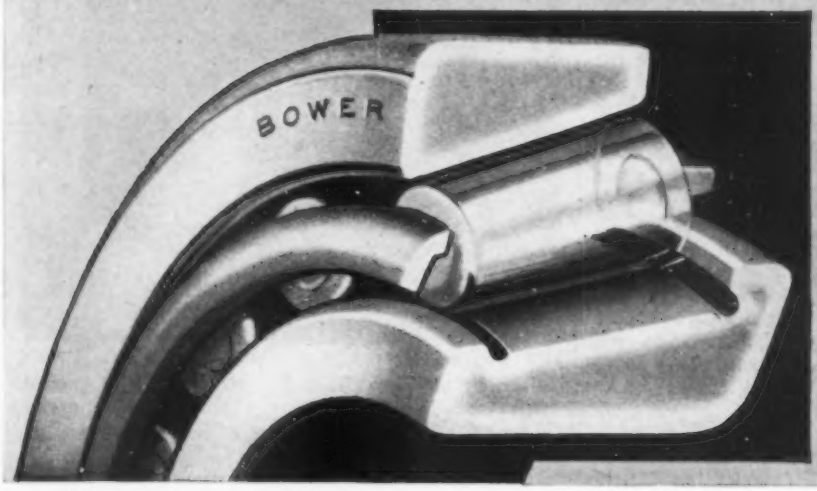
Bower spher-o-honed design provides better bearing lubrication



LARGE OIL GROOVE GIVES POSITIVE LUBRICATION TO ROLLER HEADS

The large oil groove built into Bower Spher-O-Honed bearings is just *one* of several important Bower design features which reduce maintenance and increase efficiency. Combine it with generated spherical roll-heads and a higher flange surface, and smooth, precision-honed races, and you have the basic elements of Spher-O-Honed design.

A careful look at the illustration above will show you other important Bower features, too. Note particularly that the roller heads contact the flange over a wide two-zone area—thus reducing wear and minimizing resultant "end play."

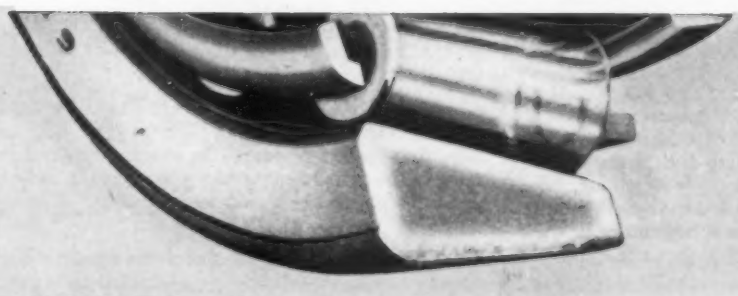
Built of the highest quality materials and workmanship, Bower bearings are available in a complete range of sizes and types to meet your present requirements. Call in a Bower engineer now!

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN

BOWER

ROLLER BEARINGS

SPHER-O-HONED



A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS

Hermetically Sealed Plug-In Meter Relay

Sealed in a round metal can, and furnished with either an octal plug connector or other type of sealed header, this non-indicating meter-relay has a balanced movement, self-locking contacts, and sensitivity as great as 0.2 microamperes. The jeweled movement of this device is shock mounted.

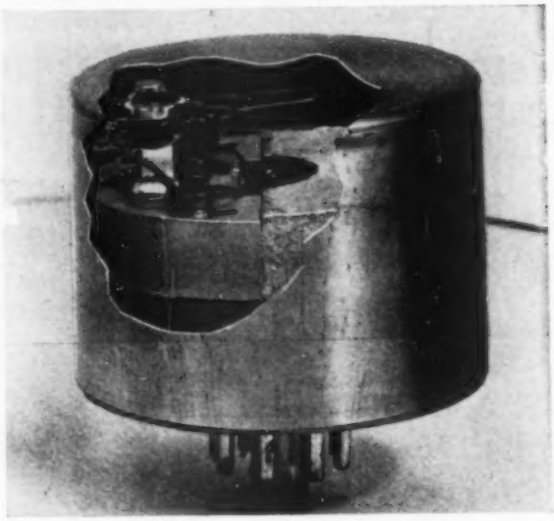
Sensitivity ranges are listed from 0.2 microamperes to 50 amperes, or 0.05 millivolts to 500 volts. Copper oxide or crystal diode rectifiers are used for a-c operation. Rectifiers or R. F. thermocouples can be included inside the sealed case, or they may be used externally.

Contracts lock in by a holding coil in the relay, and are released by breaking the circuit to the holding coil. Contacts are rated 5 to 25 d-c milliamperes at 75 to 125 volts. The contact current energizes the holding soil. Contact arrangement is single pole single throw, or single pole double throw.

Accuracy is adjusted to within 3 percent of the specified voltage or current. By adjusting circuit resistance the accuracy can be improved to within 1 percent.

While design variations allow a range of response time from 1 millisecond to 10 seconds, most ranges will have a response time of a few milliseconds. Time delay can be calibrated in seconds or milliseconds.

Calibrated in millivolts and with bimetal compensation, this relay gives accurate control of temperature or safety alarm when used with standard temperature thermocouples. Double contact relays, single pole, single throw, have both high and low limit for over or under control.



Also made by this company is a complete control assembly for use where only one meter will show on the panel.

Assembly Products, Inc., Chagrin Falls, Ohio

Versatile, High-Speed Digital Recorder

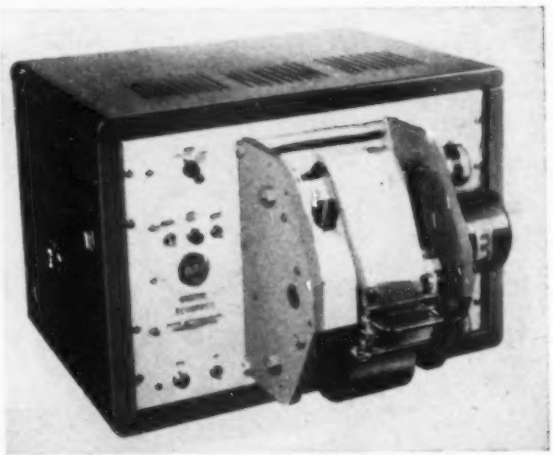
High-speed, permanent recording, in the vicinity of up to 150 eight digit numbers per second, has been designed into a new digital recorder for use with any of the line of Counter-Chronographs, Frequency-Time Counters, Scalers, made by this company or any similar equipment which provides a binary coded decimal indication.

Data, obtained from measurements in ballistics, frequency phenomena, telemetering, geophysical observations, aerodynamics, and related fields, are recorded on electrosensitive paper of the Western Union type by groups of four styli. Each stylus in a group corresponds to a lamp in the 1-2-4-8 binary, making a simple, easily read, and permanent data record.

To conserve paper and improve readability, an intermittent drive system advances paper, controlled by the data input, at recording speeds below ten per second. The intermittent motion automatically merges into a continuous drive at speeds above ten records per second. Provision is also made for continuous drive independent of the data input.

The paper speed is adjustable from 2.5 to 20 in. per sec to fit a variety of recording requirements. Standard paper rolls, 4¼ in. by 400 ft, allow over 50,000 recordings to be made without reloading. Rigid end plates maintain alignment and reduce maintenance to a minimum, while accessibility has been increased and loaded time reduced.

The model 960 Digital Recorder is now made in standard units featuring 20, 26, or 32 styli, but any number of channels up to 32 can be made available. Dimensions are 17⅛ in. wide, 12¼ in. high, and 16¾ in. deep. A rack mounting bracket kit adapts the recorder to standard 19 in. relay racks, permitting access to the unit on slides. Power input is approximately 300 watts.



Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N. Y.

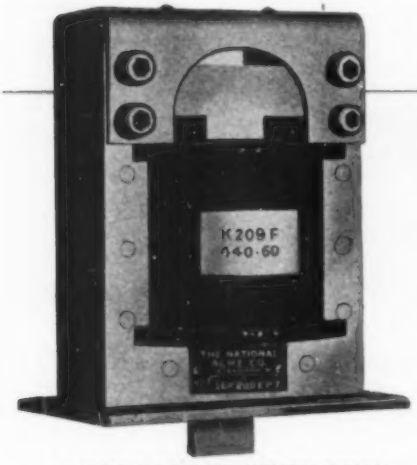
CONTINUED ON PAGE 236

doing a job automatically?

BY REMOTE CONTROL?

IN CRAMPED QUARTERS?

actuate clutches	print symbols	operate valves
operate switches	operate safety devices	vibrate cutting knives
control machines	eject work in process	open and close doors
move levers	actuate clamping	open and close hoppers
	hold chucks	sort inspected parts



SADDLE STOP LIMITS PLUNGER RETURN

A leather faced saddle type retainer stop is available for all standard series Namco push type solenoids. This plunger retainer acts as a positive stop to gauge the length of stroke, also as a cushion to reduce noise and absorb impact forces when the plunger is subjected to a severe return blow.

Like More Details?

Engineering Bulletin No. EM-52 shows many standard and special Namco solenoid applications, also dimensions, types of mountings, ratings and other useful data. Ask for your copy.

then you need NAMCO

"STELLITE"-WELDED

Solenoids

Solenoids offer you a modern, up-to-date way of doing jobs automatically—by remote control, even in cramped quarters.

With the positive, accurate action of Solenoids you can simplify design, manufacture and operation. They're taking the place of expensive, bulky gear trains, levers, linkages and other mechanisms. Many a manufacturer with a cost or space problem, has found the solution in Namco Solenoids.

Namco Solenoids with "Stellite"-Welded contacts, are compact, rugged and reliable. We'll be glad to recommend the size and style best suited to your job—with standard or special terminal blocks and mountings.

Namco "Stellite"-Welded Solenoids are built in sizes with ratings from 2½ to 25 pounds, push or pull, at 1" stroke; combination push-pull and other special applications are available. Either AC or DC type may be specified.

ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME CO.

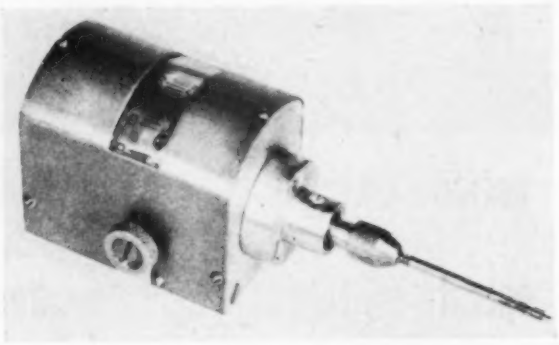
170 EAST 131st STREET • CLEVELAND 8, OHIO

ACME-GRIDLEY BAR AND CHUCKING AUTOMATICS (1-4-6 AND 8 SPINDLE) • HYDRAULIC THREAD ROLLING MACHINES • AUTOMATIC THREADING DIES AND TAPS • LIMIT, MOTOR STARTER AND CONTROL STATION SWITCHES • SOLENOIDS • CONTRACT MANUFACTURING

Small, Sensitive Torsion Tester

Designed for testing clockwise or counter-clockwise torque or both, and for field checking light spiral and torsion springs, this small torsion tester weighs about one-half pound, and measures only 1½ x 1½ x 2½ inches. The model shown was designed as a lightweight field maintenance tool for aircraft cameras, and is used to test the point of torque at which the two shafts will slip.

This tester is built around a precision calibrated elastic spiral spring mounted on a shaft which is seated in two precision low torque bearings. Its capacity is 40 gram centimeters, and the dial is graduated in increments of 2 gram centimeters. At this capacity, the inherent frictional error due to the bearings is only ¼ gram centimeter. By using different springs this tester can be made in almost any capacity. The tester is operated by turning the chuck with the fingers. It also has a zero-setting adjustment.



John Chatillon & Sons, 85 Cliff St., New York 38, N. Y.

Subminiature Blowers Mounted on Component

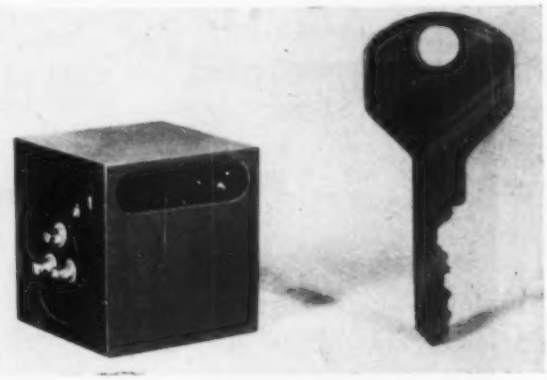
This one inch wide subminiature blower, weighing only one ounce includes the motor and blower housing, and delivers 3 cu ft of air per minute. Intended for subminiature applications, its universal mounting, small size, and light weight permit the unit, known as the Minicube, to be used in almost any type of equipment.

It was designed for the circulation of air and the cooling of electronic parts and equipment, and can be mounted next to a component for spot cooling or anywhere else for the general circulation of air.

The Minicube blower can be used in hermetically sealed equipment for heat transfer to or from the case. Mounted on the inside, the blower is used to transfer heat to the case.

Mounted on the outside it can be used to remove heat from the case. The manufacturers claim that the blower can replace large external blowers for cooling klystrons and magnetrons.

Standard models are available for operation over a temperature range of —55 to +85 C, with an expected life of 1,000 hours. Other models are also available for wide temperature ranges. The small blower uses an integral hysteresis type synchronous motor turning at a speed of 24,000 rpm and motors can be supplied for either 6.3 v, 3 w, or 26 v, 4 w, 400 cycle operation. The motor is normally 2 phase, but can be operated from a three or single phase source with a phase shifting capacitor.



Sanders Associates, Inc., Nashua, New Hampshire

A MINIATURE CIRCUIT BREAKER that fits like a fuse in any standard base fuseholder, is now available in a 10 amp rating for use with small motors used in appliances, blower fans, and similar applications. Called the Minibreaker, it safely interrupts excessive overloads and short circuits, tripping on shorts, yet having a time lag to handle temporary starting overloads and line surges. Mechanical Products, Inc., 1824 River St., Jackson, Mich.

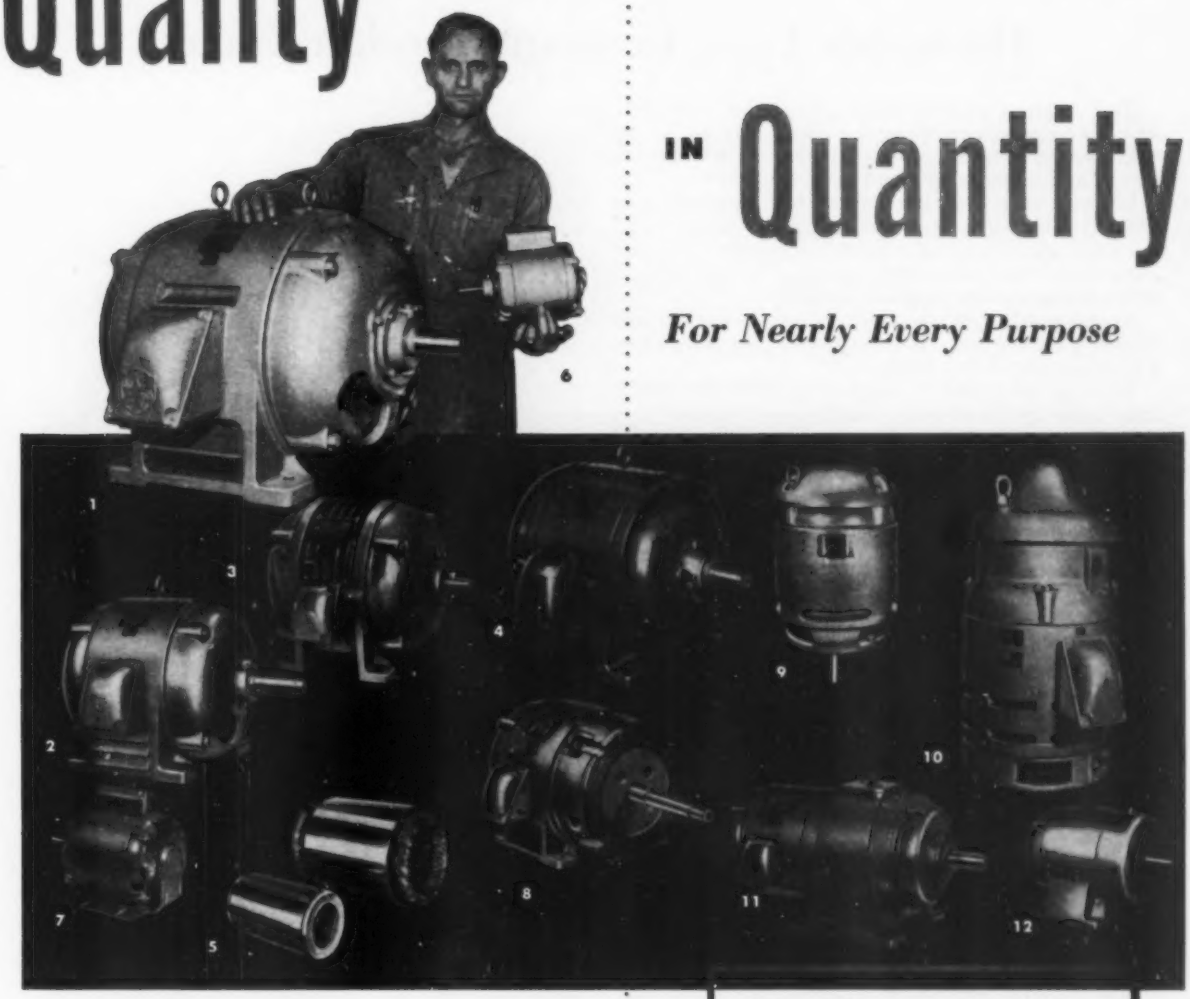
NEW SAFETY FEATURES of an improved type explosion chamber are: automatic fuel metering, which eliminates the hazards of manual metering, and a tank constructed to ASTM standards. The chamber also has a special ignition circuit, whereby firing of the gaseous atmosphere is possible at any altitude up to 70,000 feet. Windows permit observation during testing. Bowser Technical Refrigeration Co., Terryville, Conn.

SELF-CONTAINED, PORTABLE, hydraulic weighing units, accurate to 0.1 percent of scale, are now stocked in sizes up to fifty tons, permitting accurate force measurement anywhere in the plant, and on the job. Portable units are now available in 24 ranges from 0-500 pounds to 0-100,000 pounds, and there are four load cell sizes with a choice of 8½ in., 12 in., and 16 in. indicators. The A. H. Emery Co., New Canaan, Conn.

CONTINUED ON PAGE 238

Quality MOTORS IN Quantity

For Nearly Every Purpose



Mechanical Types: Drip-proof (1); Splash-proof (2); Totally Enclosed Non-Ventilated (3); Totally Enclosed Fan-Cooled (4); Rotors and Stators (5); Rigid Base (6); Resilient Base (7); Flanged (8); Vertical Solid Shaft (9); Vertical Hollow Shaft (10); Gear Motor (11); Special Purpose (12).

Electrical Types: Fractional H.P. ¼ to ¾. Integral H.P. 1 through 500. Single phase. Polyphase. Normal Slip. High Slip. Normal Torque. High Torque.

A. O. SMITH offers you quality motors in a wide range of types and sizes from ⅓ H.P. to 500 H.P. Proof of quality is demonstrated daily by hundreds of thousands of units which furnish power for all kinds of useful work. Service throughout the nation is provided by hundreds of Authorized A. O. Smith Motor Service Stations. Write today for information on standard or special types. A. O. Smith Corporation, Electric Motor Division, 5715 SMITHway St., Los Angeles 22, Calif.

A.O.Smith

ELECTRIC MOTOR DIVISION

Hysteresis Type, Constant Tension Brakes

Two magnetic tension brakes of the hysteresis type, with torque ranges of 0.4 to 4.0, and 2.0 to 14.0 oz-in. will supplement the original brake made by this company which has a torque range of 0.1 to 0.5 oz-inches.

Designed to give constant tension and reduce abrasion and excess flexing of synthetic and natural yarns as well as rubber, glass fiber, and wire, the larger sizes of the new brakes make them particularly adapted for use on a loading device where constant torque is required.

Approximately two and three inches in diameter and weighing about $\frac{3}{4}$ and $2\frac{1}{2}$ lb respectively, the brakes have a speed range of 0 to 1,500 rpm.

Although no pulley is supplied as with the smaller brake made by this company, which has a torque range of 0.1 to 0.5 in-oz, the torque adjustment is the same. Turning the calibrated aluminum magnet housing decreases or increases the torque of the brake by altering the distance between four Alnico magnets and a hysteresis ring. Calibration is accurate to 0.5 gram at any point over the range of adjustment.

The brake holds stalled tension by a tendency to reverse direction of rotation for a few degrees after decelerating to a standstill. Tension will remain in the standstill or in the off position.

Because the braking action is provided by a magnetic field, there are no rubbing parts to wear, and the unit will retain the required torque unaffected by lint, moisture, and heat. All brakes are calibrated, and will hold constant torque almost indefinitely unless disassembled or subjected to a strong external magnetic field.

General Electric Co., Schenectady 5, N. Y.

Miniature High Shock Relays

Miniature high shock relays for aircraft, guided missiles, switching devices, motor starting devices and others, are hermetically sealed in metal cans, and will surpass the requirements of MIL-5757B. Structure gives maximum resistance against shock and vibration. Its maximum size is $1\frac{5}{32}$ in. dia by $1\frac{13}{16}$ in. long. Weight is 3.2 ounces. The types are: HG-2 (2 PDT) and HG-4 (4 PDT).

Specifications: Temperature range: —65 to +500 F; Coil voltages: 6 to 300 volts; Coil resistance: 8 to 20,000 ohms; Contact rating resistance load; 28 v d-c, 4 amp and for 115 v, 60 cycles, 4 amp; Contact resistance: 0.010 to 0.030 ohms available depending upon application; Breakdown voltage: 1,000 v, 60 cycles; Shock resistance: 100 G plus. The sensitivity of the relays may be increased where the shock requirements are below 100 G.

Hi.G, Inc., Bradley Field, Windsor Locks, Conn.

IMPREGNATING LEATHERS with oil resistant liquid polymers, followed by further polymerization within the leather, has resulted in a material that not only retains all the good properties of leather, but also permits complete control of porosity. Called Conpor, the material has flexibility, strength, stability, resistance to oils and solvents, is flexible at low temperatures, and ages well. Impregnation of the leathers ranges from zero to 100 percent, based on the leather's original porosity. With a variety of formulas, they are available in full thickness or limited-depth impregnations. Chicago Rawhide Mfg. Co., 900 N. State St., Elgin, Ill.

CONTINUED ON PAGE 240

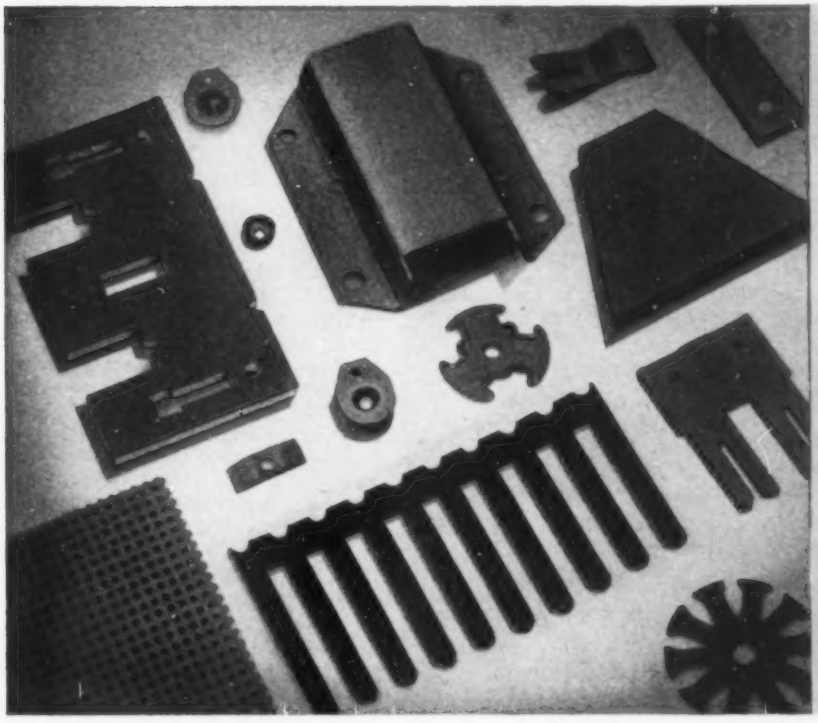
TAYLOR ***Commercial Grade Vulcanized Fibre***
is tough, lightweight, abrasion resistant . . .
excellent for bending, punching, stamping and forming . . .
resistant to organic solvents, oil and gasoline . . .
has excellent electrical characteristics.

Want to make something of it?

Make it into insulating plates, upset washers, arc barriers, terminal blocks, switch and appliance insulation, cases, face plates for golf clubs . . . or any other electrical or mechanical component that can benefit from the unique properties of this versatile material.

Make it in red, gray, black, or special colors.

Make it from sheets or rolls with these specifications:



SPECIFICATIONS

Thickness Range:	.005″ to 1″
Finish:	Pressed and calendered
Punching:	To 3/16″ thick
Sheet Size:	56″ x 90″
Roll Width:	56″ for thicknesses of .005″ through .060″. Coils to 3/16″ for thicknesses of .005″ through .090″.

PROPERTIES

Mechanical	
Flexural Strength	
(Lengthwise)	14000 psi min.
(Crosswise)	12000 psi min.
Tensile Strength	
(Lengthwise)	7900 psi min.
(Crosswise)	5500 psi min.
Compressive Strength	
(Flatwise)	20000 psi min.
Izod Impact Strength	
(Lengthwise)	3.5 Ft.-Lbs./inch
(Crosswise)	2.9 Ft.-Lbs./inch
Electrical	
Dielectric Strength	
(1/32″ thick)	250 min.
Short Time Test	
(1/8″ thick)	175 min.
Arc resistance, seconds	100

Make it from turned rods. Diameters from 1/8″ to 1″ with ground or buffed finish.

Make it easy for yourself when you're buying vulcanized fibre. Call your Taylor engineer . . . he will be glad to work with you . . . help select the correct grades to fit your needs —Commercial, Bone, Super White, Abrasive and Built-up. Also ask him for samples of Taylor Laminated Plastics . . . *Phenol, Silicone and Melamine Laminates* . . . suited for a variety of your product requirements.

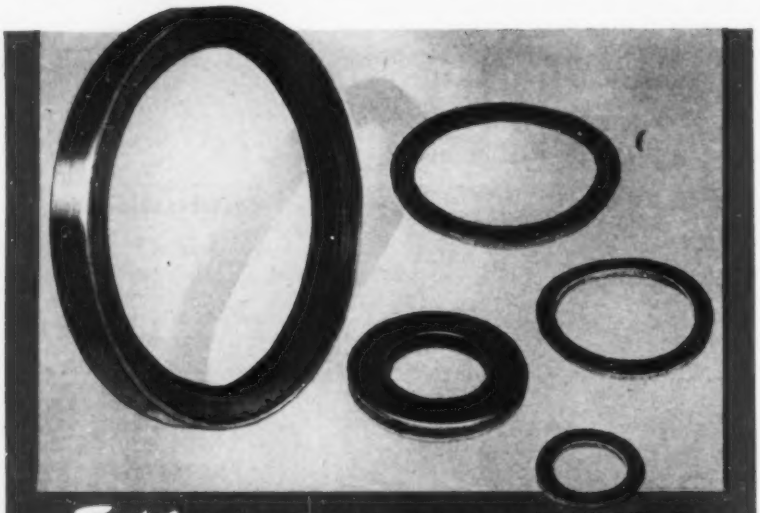
Taylor Fibre Company, Norristown, Pennsylvania — La Verne, Calif.

TAYLOR
Laminated Plastics
Vulcanized Fibre

Thiokol® LIQUID POLYMER LP-2

BUILDS PERFORMANCE INTO

conpor® OIL SEALS and PACKINGS



Thiokol LIQUID POLYMER LP-2 IS A SOLVENTLESS LIQUID THAT CONVERTS TO A RUBBER AT ROOM TEMPERATURE WITHOUT SHRINKAGE.

Conpor is a "Thiokol"—impregnated leather oil controlled recently developed by the Chicago Rawhide Manufacturing Company. Conpor oil seals and packings possess the remarkable ability to seal and lubricate at the same time.

The following properties of compounded and cured "Thiokol" LP-2 help build outstanding performance into Conpor oil seals and packings:

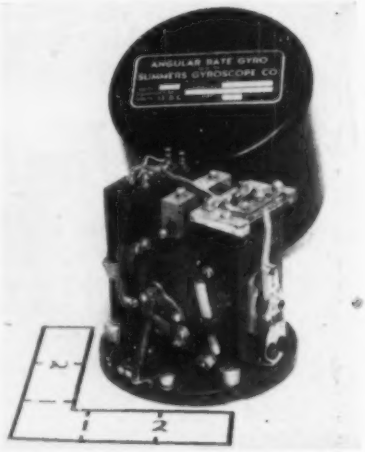
- EXTREME OIL AND SOLVENT RESISTANCE
- EXCELLENT AGING PROPERTIES
- BROAD OPERATING TEMPERATURE RANGE
- TOUGHNESS AND RESILIENCE
- IMPERMEABILITY TO GASES AND MOISTURE
- HIGH BOND STRENGTH

The desirable properties of "Thiokol" LP-2 may help you build performance into your product. In addition to its use in leather impregnation, "Thiokol" LP-2 does an outstanding job in sealing, potting, casting and adhesive applications. Write for technical information and samples.

Thiokol Chemical Corporation supplies "Thiokol" LP-2 only as a raw material. We will gladly indicate sources of supply of finished products to end-users.

Thiokol Chemical Corporation

784 NORTH CLINTON AVENUE, TRENTON 7, NEW JERSEY



Gyro Measures Angular Rates of Rotation

This model 70 rate gyro, a sensitive device designed to register angular rates of rotation, is made with coil spring or torsional rod restraints to limit the rotation of the gimbal about its axis, depending on the range desired. Variations of this model are manufactured with or without damping and hermetic sealing.

Change in potentiometer resistance on this gyro is directly proportional to the angular rate about the input axis. The unit has been designed to operate on 12 v or 28 v d-c power and 400 cycle, 110 v a-c power. The electrical output signal of this gyro may be used for telemetering and control.

It measures $3\frac{5}{16}$ in. x $3\frac{9}{32}$ in. in dia, and weighs $1\frac{1}{4}$ pounds. Power consumption is small.

Summers Gyroscope Co., 2328 Broadway, Santa Monica, Calif.

All Metal Vibration And Shock Mount

To handle the severe vibration and acceleration characteristics of guided missiles, a new special double-acting unit mount has been designed featuring: non-linear deflection characteristics; high damping; low amplification at resonance; and ability to withstand any conditions of temperature and environment.

Made with an all-metal cushioning material, the mount is suitable for the isolation of vibration and shock for positive, negative, and radial loads, thereby protecting sensitive components.

Load ranges are available between 1-7 lb per mount, and a range of

Announces

A New Cold-Rolling Mill producing TRUSPEC Aluminum Strip To meet today's demand for high quality and close tolerances.

For years, Scovill engineers have sought dependable methods of controlling grain size, temper, directional properties and dimensions in aluminum strip *to the same precision standards long since established for Scovill Brass Strip.*

Today, TRUSPEC, Scovill's Aluminum Strip produced on this brand new cold-rolling mill, fully measures up to these standards.

We invite you to contact your nearest Scovill branch office for a copy of our TRUSPEC Aluminum Strip brochure giving you complete details . . . including technical data and specifications of available alloys.

A trial run will show you to what an important degree Scovill TRUSPEC Aluminum Strip will aid you in making it possible to minimize "orange peel" effect and "earing." Extra long coils also help in reducing press down-time.

SCOVILL MANUFACTURING COMPANY, WATERBURY 20, CONNECTICUT

Contact your SCOVILL *nearest office*

BOSTON AREA
1116 Great Plain Avenue
Needham 92, Mass.

CHICAGO 51, Illinois
4105 West Chicago Avenue

CINCINNATI 2, Ohio
49 Central Avenue

CLEVELAND 2, Ohio
6516 Detroit Avenue

DETROIT 7, Michigan
6460 Kercheval Avenue

LOS ANGELES 23, California
2627 South Soto Street

NEW YORK 17, New York
Chrysler Building East
161 East 42nd Street

PHILADELPHIA 22, Pennsylvania
1419 North Broad Street

PROVIDENCE 3, Rhode Island
183 Public Street

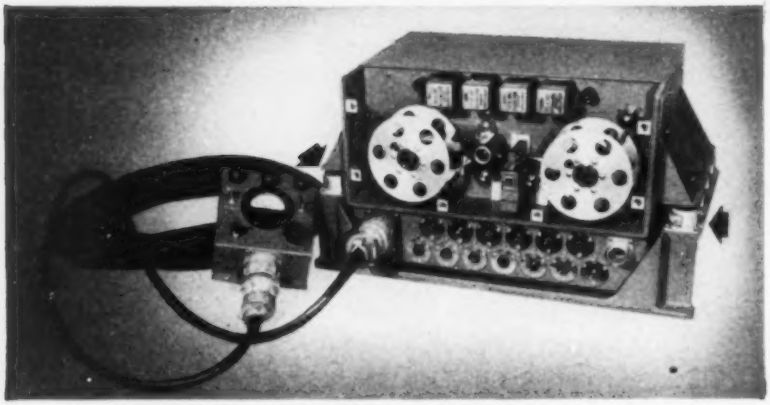
ROCHESTER 4, New York
Hiram Sibley Building
311 Alexander Street

SAN FRANCISCO 7, California
434 Brannan Street

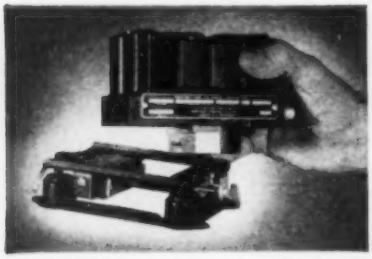
STURGIS, Michigan
Congress Street

SHOCK – VIBRATION – NOISE

ISOLATION NOTES



UNDISTORTED FLIGHT DATA are recorded by this Davies Laboratories aircraft data recorder. Tubes, relays, and recorder mechanism are protected against vibration by air-damped BARRYMOUNTS.



70% SIZE REDUCTION and 50% weight reduction, with no loss in performance, is achieved in this Minneapolis-Honeywell aircraft-fuel-gage power unit. Miniaturized air-damped BARRYMOUNTS helped make this saving possible, in protecting the reliability of the unit from vibrations and shock.

SENSITIVE ADJUSTMENTS ARE HELD when instrument and control panels are mounted on BARRYMOUNTS. Vibration from nearby heavy machinery cannot shake equipment out of calibration. Result: insured reliability of equipment and service.

NO SHIPPING DAMAGE, plus simplified packing, is Philco's experience with BARRYMOUNTS built into the packaging of microwave equipment. Pre-assembled equipments, with tubes and crystals in place, are shipped all over the world without damage, thanks to this modern packaging method. Write us for details.

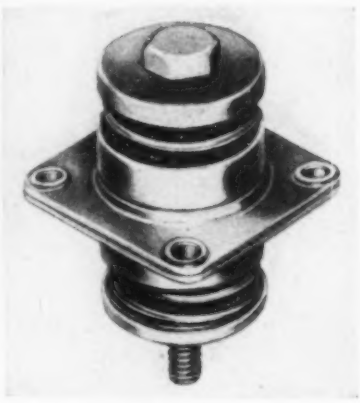
The wide range of Barry products and the experience of Barry engineers can help you solve shock, vibration, and noise problems in any area of military or industrial activity. Call our nearby sales representative or write directly to us.

THE **BARRY** CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Baltimore Chicago Cleveland Dallas Dayton Detroit Los Angeles Minneapolis New York Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington



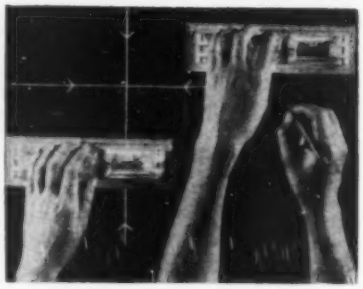
natural frequencies above 10 cycles per sec can be provided depending on the load and performance requirements. A smaller size unit is available for light equipment.

Robinson Aviation, Inc., Teterboro, N. J.

Pocket-Portable Drafting Instrument

The Glide-Rule, a new transparent drawing instrument capable of rolling in two directions, combines most of a draftsman's tools in one—triangles, T-squares, straight edge, scales, protractor, and parallel rules.

A small instrument, measuring 2½ by 9 in., it has accurate engraved scales and protractor; four drawing edges



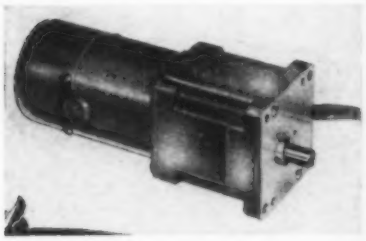
with scales in 16ths and 20ths; and emphasized 30, 45 and 60 deg angles on a full 180 deg protractor.

The instrument rolls both up and down, and right and left, with a small thumb button permitting the user to change direction.

Smith Drake Corp., 1206 *S. LaBrea Ave., Inglewood, Calif.*

Light-Weight Rotary Actuator Has Torque Limiting Device

A compact, light-weight rotary actuator of comparatively simple design



provides rotary output up to 15 w at speeds from 16 to 195 rpm, with a maximum permissible torque of 25 lb-inches. It features an integral, slipping-gear type, torque limiting device which prohibits unit damage through overloading or jamming.

Measuring approximately $1\frac{3}{4}$ in. square x $5\frac{1}{4}$ in. length without filter, it is particularly suited for applications where space is limited. It weighs only 0.95 lb without the filter.

The unit was designed to the requirements of USAF specifications and is driven by a standard 26 v, d-c motor made by this company, including a brake, or combination clutch-brake, to aid in more accurate positioning.

Optional in this unit are: a radio noise filter; motor thermal protection; end position limit switches; output shaft configuration; speed and torque (within range mentioned); and AN connector.

Lear, Inc., Grand Rapids Div., 110 Ionia Ave., N. W., Grand Rapids, Mich.

Furnaces for Precision Heat Treating

Designed for a temperature range of from 300 to 2,000 F, and in 220 and 440 v models, this compact heat treating furnace has been designed specifically for precision heat treating and general laboratory work. Inside dimensions of the various models range from 6 in. wide x 6 in. high x 9 in. deep, to 10 in. wide x 8 in.

WELDMENTS
CAN SAVE YOU MONEY!

Acme weldments are replacing castings for leading machinery and equipment manufacturers everywhere because they do a better job at lower cost. Experienced Acme engineers at work with Acme's complete fabrication facilities can give *you* these same advantages . . . Acme's new 24-page, illustrated booklet shows you why. ***The Facts about Weldments and Castings*** tells you what you should know about their relative strength, rigidity, vibration, design flexibility, and cost . . . facts to help you specify and save. And it's yours for the asking . . .

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- A.S.M.E. Qualified Welders
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Smooth, Quiet, Precision

Smooth, Fast, Drag-free

STOPS! STARTS

THROUGH MILLIONS OF CYCLES

WITH STAR-KIMBLE BRAKEMOTORS

Stopping of a Star-Kimble Brakemotor is split-second in action, precisely timed by simple adjustments. Quiet, too — no lining screech. Low lining pressure, evenly distributed, assures long brake life. Brake is self-adjusting to compensate for lining wear — ruggedly built to withstand shock and vibration.

Braking force is spring applied, magnetically released. No linkages to cause lost motion or friction.

Starting of a Star-Kimble Brakemotor is smooth and free from drag. Small magnetic air gap assures quick brake release without high inrush current.

And Star-Kimble Brakemotors *maintain* this fast, smooth stop-start operation through millions of cycles with little or no maintenance attention. Brake and motor are *designed* together to *work* together as a single compact unit. One manufacturer, one responsibility — backed by years of experience. For details on construction, motor ratings and braking torques, write for Bulletin B-501-A.

Standard and special motors of all types, 1 to 600 hp; Marine motors ½ to 600 hp; generators and motor-generator sets, 1 to 500 kw.

STAR-KIMBLE

MOTOR DIVISION OF

LE PRINTING PRESS AND MFG. CO.

11 Bloomfield Avenue Bloomfield, New Jersey

high x 18 in. deep. Current consumption also ranges from 2 to 12 kw.

The control instrument, as well as the transformer, is completely enclosed in a cabinet on which the furnace rests. The heating elements are made of high temperature alloy wire which is non-scaling, non-flaking, and which resists attack from sulphur and its compounds. Door is of the double pivoted, plug type.

K. H. Huppert Co.,
6830 Cottage Grove Ave., Chicago 37, Ill.

Precision Decade Inductor Units

These units are particularly adaptable to design problems involving the need for precision, high "Q" inductors such as wave filters, tuned circuits, and elements in oscillators and analyzers, where the advantage of a simple method for component substitution can be obtained over a wide range.

The four basic decade steps, 1-10

mh, 10-100 mh, 100-1,000 mh, and 1-10 hy are available as single units. Each range is encased in a heavy drawn metal container which protects it and acts as an electrostatic shield.

Step switching is accomplished by the use of instrument type rotary switches, low resistance contacts, and a laminated self wiping contactor.

Torocoil Co.,
1374 Mobile Court, St. Louis 10, Mo.

Light Duty, Self-Aligning Pillow Block

New, light duty, ball bearing pillow blocks come complete in a ready-to-mount package, which includes a separable two-piece pressed steel housing, a wide inner ring ball bearing with a

Here's How SCHRADER makes Compressed Air...

CONVENIENT!

With Schrader Quick-Acting Couplers in airlines along walls, benches, columns—compressed air is "plugged-in" as readily as electricity. To connect—simply push adapter into check unit . . . to disconnect, manually turn sleeve of check unit—accidental uncoupling is impossible. They're available in many sizes, to suit your exact needs.

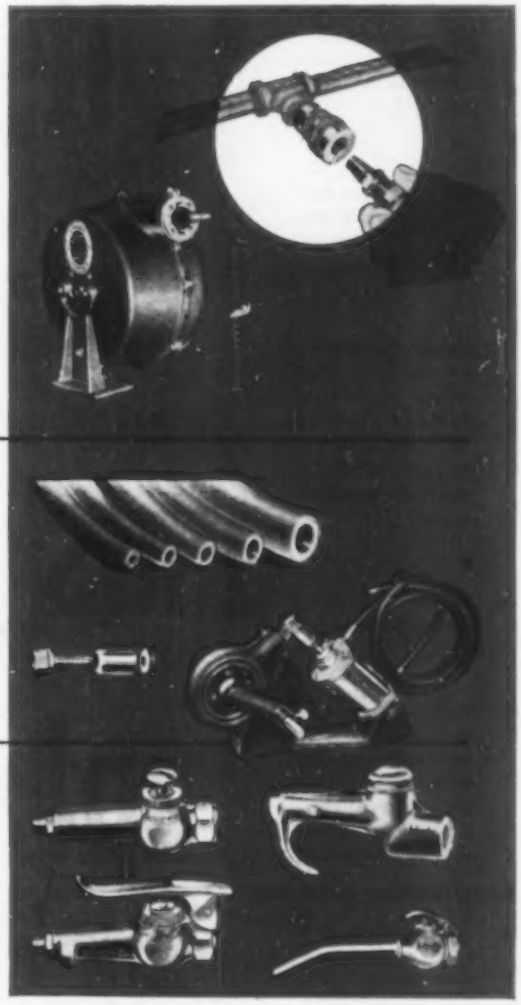
Keep idle air hose out of the way with a Schrader "Tuck-Away" Hose Reel—yet have it available at all times. Schrader Hose Reels work as easily as a window shade—and come in several sizes with up to 50' of top-quality Schrader air hose.

RELIABLE!

An air tool can be no better than the air circuit that leads to it. With Schrader Hose, Fittings and Ferrule Machines, you're sure of neat, attractive air circuits that will have long, useful lives. Whatever your air needs, you can meet them with Schrader Air Hose and Fittings.

ECONOMICAL!

Whether your air line ends in rugged, practical Blow Guns like these—or Valves, Cylinders, Ejection Sets, Press Contro's—you'll find there's a *complete Schrader Line* from which you can select the exact product to give you the maximum return on your compressed air investment. Check with Schrader and see for yourself.



REMEMBER—from air line to air tool—Schrader is *one reliable source for all air control products.* For further information on the air accessories shown here, write for Bulletin A280—or fill out the coupon below.

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+ We make the wire cloth we would use for your product... the well-known "NEWARK for ACCURACY" Cloth.

+ We offer more than 75 years experience in wire cloth manufacture and use.

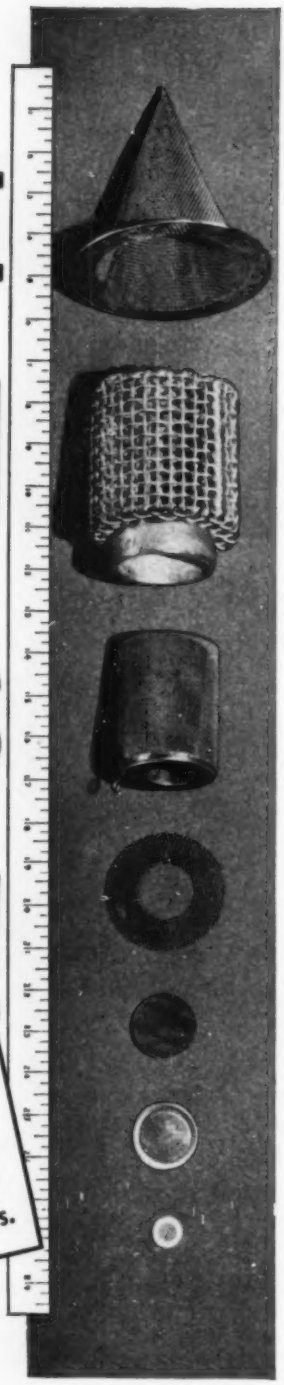
+ We have the facilities for accurately fabricating parts from NEWARK Cloth in small lots or in production quantities to meet your production schedules.

+ We have the skilled workers to do the job.

+ We have experienced engineers ready to work with you in the design of the part to make the most effective and economical use of the wire cloth.

= It all adds up to a service that can produce "quality" wire cloth inserts for you. It is the same service that has brought us many, many repeat orders and one that has been responsible for a steadily growing list of customers.

It all adds up!



... and suggests why it will pay you to let us "fabricate" your wire cloth inserts.

NEWARK for ACCURACY

We can furnish wire cloth woven from all commercially used metals. Sizes range from 4 inches (space cloth) to 400 mesh.

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, NEW JERSEY

locking collar, and a special contact seal developed by this company.

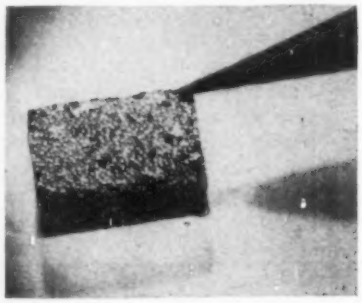
Said to occupy less space than other pillow blocks for the same shaft size, this type PB unit is designed to give initial self-alignment in all directions, and ample strength for light duty applications. Needs no lock washers, adapters, or other positioning devices.

Models available for shaft sizes from $\frac{1}{2}$ to $1\frac{1}{4}$ inches. Radial load for the smaller unit is 300 lb, and for the larger, 600 pounds.

The Fafnir Bearing Co., New Britain, Conn.

Self-Lubricating Bearing Material

A new self-lubriating metal with exceptional bearing strength is made of both ferrous and non-ferrous metals and specially formulated lubricative pigments locked together to create a self-lubricated metal. Ratio of lubricative pigment to metal can be accur-



ately controlled with maximum lubricity engineered to meet the requirements of specific bearing pressures.

The feature of the new material is the constant lubricating qualities of the metal throughout the entire mass, assuring permanent lubrication for life.

Booker-Cooper, Inc., 8487 Melrose Place, Los Angeles 46, Calif.

Miniaturized High-Frequency High Speed Alternators

High power outputs for their size and weight is the feature of a new line

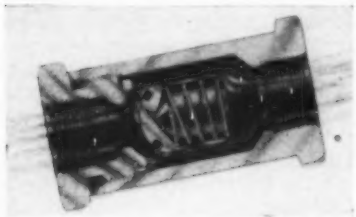
of miniaturized high-frequency alternators having operating shaft speeds from 10,000 to 50,000 revolutions per minute. The present line includes units with power output ratings from 125 watts to 4,000 watts at 5,000 cycles per second.

As an example, the model A-17 unit, shown above, measures 2½ in. in diameter, weighs 22 ounces and delivers 350 watts output at 5,000 cycles with a shaft speed of 25,000 revolutions per minute.

D & R, Ltd., 402 E. Gutierrez St., Santa Barbara, Calif.

Check Valve With Low Pressure Drop

A spherical poppet nose and matching seat in a new free-flow check valve always give a perfect leak-proof seal, because they are self-aligning. The caged poppet is said to give lower-than-ever pressure drop, practically no



flow restriction, in non-surge hydraulic systems to 3,000 psi. While the standard opening pressure is as low as 3 oz, stronger springs are available so these units can be used as combination in-line relief-check valves.

Available in all combinations of tube and pipe ports, for operating temperatures —65 to 200 F; and higher on order. Made in all metals, in sizes ⅛ to 1 inch. For more information on this and other check valves, write to the manufacturer.

Republic Mfg. Co., 1930 West 77 St., Cleveland 2, Ohio

O & S SELF-LUBRICATING BEARINGS

DON'T JUST DOODLE..

When You're thinking about parts that are DIFFICULT or IMPOSSIBLE to LUBRICATE . . .

DROP OSBEAR THE LUBRIKON A NOTE . . .

NeverOil SINCE 1913

O&S

ACE MANUFACTURING CO.
406 E. LOBB ST MISFALLY, MO.

Dear Osbear:
We need help on a bearing problem. All plans and details are enclosed.
Yours Truly
Jim Morgan
Chief Design

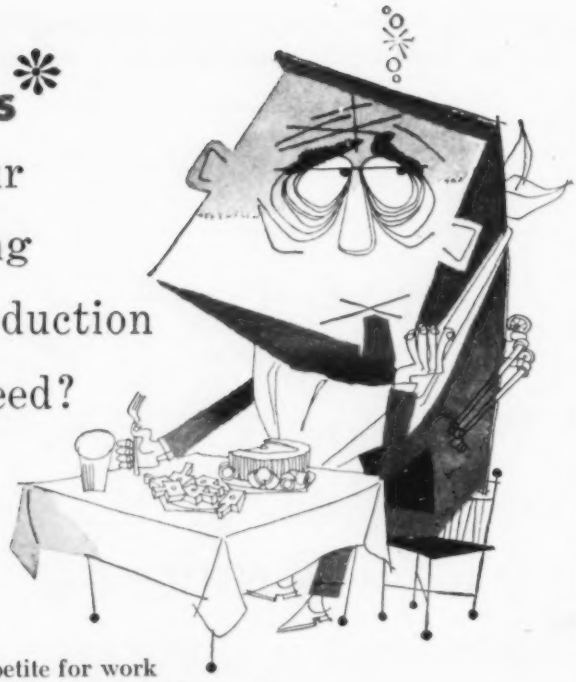
NeverOil SINCE 1913

O&S BEARING & MFG. CO.
777 W. EIGHT MILE ROAD • WHITMORE LAKE, MICHIGAN

does

coil-itis

have your processing tank production off its feed?



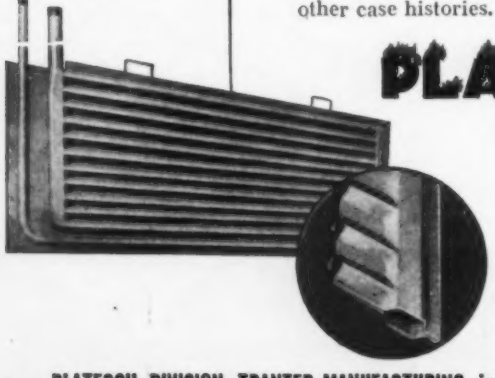
When the appetite for work of your heating and cooling processes diminishes, the trouble may well be coil-itis. For, downtime due to pipe failures and limitations can seriously delay your production flow. Switch to Platecoils, the new tonic for production, as revolutionary as the new wonder drugs. Platecoils take 50% less tank space leaving more room for greater payload. They heat or cool 50% faster. They simplify maintenance and save hours of downtime. Equally important, Platecoils cost as much as 50% less in the first place. Platecoils cure production troubles involving heat transfer and give production a shot in the arm.

Write for Bulletin P77 today!

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS ELIMINATE A 6-TO-8 HOUR-A-DAY CHIPPING JOB

At Sealed Power Corp., installation of Platecoils has completely eliminated a 6-to-8 hour-a-day chipping job. Three Platecoils now heat a tank that previously took 4 pipe coils. Ask about other case histories.



PLATECOIL

REPLACES PIPE COILS

Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

PLATECOIL DIVISION, TRANTER MANUFACTURING, inc., LANSING 4, MICHIGAN

New Parts and Materials.....continued

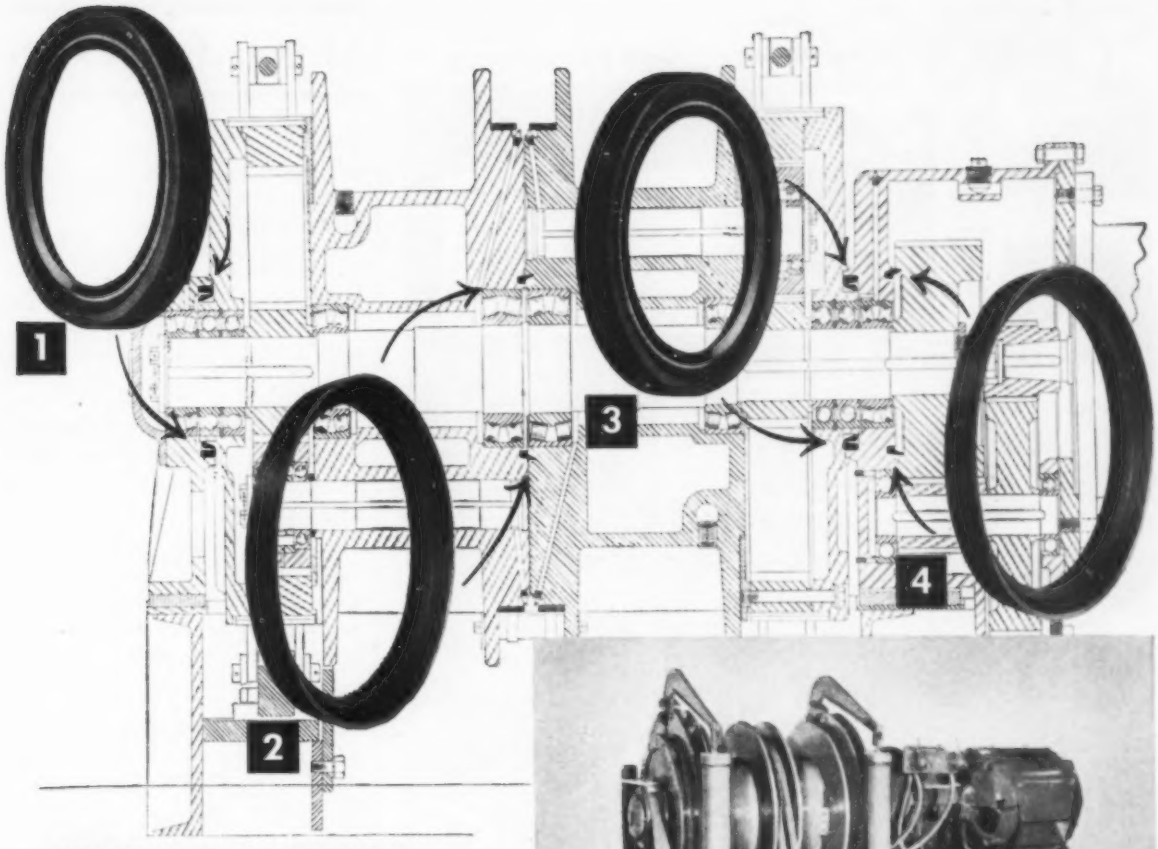
WIRE CABLES made in sizes from $\frac{3}{64}$ to $1\frac{1}{8}$ in. in dia, are now being covered by a thin coating of nylon which is extruded solidly around the core of the cable. It is said to greatly increase the cable life, and withstands abrasion, kinking, and corrosion. The nylon coating is available in many colors. Rochester Ropes, Culpeper, Virginia.

A HEAT RESISTANT PAINT that retains a good appearance, even after hard usage, has a black finish designed to withstand temperatures of 1,000 F. One application to date includes the painting of an exhaust manifold on an automobile engine. Midland Industrial Finishes, Waukegan, Ill.

THE MODEL J MIDGET TORQUE SCREWDRIVER is a small, light-weight tool with a predetermined torque setting. It is manufactured with an interchangeable handle and can be supplied with a jeweler's finger guide or with a knurled type. Applications include: camera mechanisms; indicators; clocks; switches; potentiometers; small electro-mechanical mechanisms; relays and similar devices. This tool is factory preset to any desired torque requirement. Torque adjustment screws make it possible to adjust this screwdriver to the exact required torque within a given range. Overload Control Co., 260 Langston Ave., Glen Oaks, L. I., N. Y.

FIBERGLASS REINFORCED POLYESTER SHEETS now available in sizes up to $4\frac{1}{2}$ x $8\frac{1}{2}$ ft, and in a variety of thickness, are made in two grades: grade I, 20,000 psi and grade II, 40,000 psi. Both grades have good dimensional stability and resistance to a variety of chemicals, making them applicable for structural elements in corrosive atmospheres or baths. The materials also exhibit high arc resistance and low power factor, permitting use in the electrical and electronic industries. The material can be formulated in varying degrees of flexibility. Strick Co., Plastics Div., Whitaker & Godfrey Aves., Philadelphia 24, Pa.

A NEW AUTOMATIC VARIABLE PITCH PULLEY AND CLUTCH is adaptable to a wide range of uses with both electric motors and gasoline engines. It has only one moving part whose wear could affect the operation of the clutch. In operating principle, it uses the centrifugal force of a revolving ball column and has no springs or fluids. Shaft sizes $\frac{1}{4}$ to $1\frac{3}{8}$ in. dia., and hp ratings from $\frac{1}{4}$ to 7.5. Pulley diameters from 2 to 7 inches. The Hoover Pulley Co., Williamstown, Mass.



A TYPE OF OIL SEAL FOR EVERY SERVICE
The J-M Clipper Seals used in Joy Manufacturing Company's Double Drum Slusher Hoists are: (1) Type LPD for planetary clutch-hub to bearing-bracket seal, (2) Special Outside Lip Seal Between counter-rotating drums, (3) Type LPD seal as reduction gear housing to planetary clutch-hub seal, (4) Special Outside Lip seal for reduction gear housing seal.

Need an oil seal to withstand muck and acid mine water?

Clipper Oil Seals help Joy Mine Slushers stay underground longer

THIS 125 H.P. Double Drum Slusher Hoist made by Joy Manufacturing Company is one of the most rugged machines in underground mining service. Designed to haul rock and ore in metal mining operations, it is constantly covered with muck and mud. In addition it is subjected to acid mine waters. To work dependably, shift after shift, day after day, it must stay clean and well lubricated on the inside.

To protect its bearings from dirt and corrosion and to retain the lubricant, two types of Clipper Seals are used. Type LPD Clipper Seals with corrosion-resistant alloy garter springs are installed on the reduction gear housing to planetary clutch and on the planetary clutch hub to bearing housing. Special outside lip springless Clipper Seals are installed between the counter rotating drums and on the reduction gear housing. This combination was effected by Johns-Manville Packing Engineers working in conjunction with the Joy Manufacturing Company engineering staff.

Clipper Seals offer many advantages, wherever accurate fit, longer life and greater sealing effectiveness are required. These precision-moulded oil seals provide easy installation, because the tough, dense heel affords just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

Clipper Seals come in a wide variety of designs, to meet practically any sealing requirement. For details write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ont.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville CLIPPER OIL SEALS**

SHENANGO Centrifugal CASTINGS ... KEY TO SAVINGS

Centrifugally cast Meehanite Metal rams for meat rendering presses. The finer, more evenly dispersed graphite flakes in these Shenango cast Meehanite Metal parts avoid stress concentrations and permit finer finishing.

Bring down overhead the SHENANGO way!

Here are two reasons why Shenango parts will cut costs for you:

First, the high-strength, pressure-dense castings produced by Shenango's centrifugal process... castings free from sand inclusions, blowholes and other defects ... are keeping work stoppage, lost production and premature part failure to a minimum for Shenango users everywhere.

Secondly, modern facilities and skilled workmen at Shenango turn out precision-machined parts *exactly* to your specifications. A real saving in time and money over parts that *almost* fit perfectly.

Send for free bulletins. All sizes and types of symmetrical parts are produced by Shenango in rough, semi- or precision-machined finish. Bulletin No. 150 covers nonferrous metals; Bulletin No. 151 covers Meehanite Metal, Ni-Resist and special iron alloys. *Write to...*

SHENANGO-PENN MOLD COMPANY
Centrifugal Castings Division
Dover, Ohio
Executive Offices: Pittsburgh, Pa.

SHENANGO

ALL RED BRONZES · MANGANESE BRONZES · ALUMINUM BRONZES
MONEL METAL · NI-RESIST · MEEHANITE® METAL

MEETINGS

November 9-12

REFRIGERATION AND AIR CONDITIONING EXPOSITION—Public Auditorium, Cleveland, Ohio.

November 17

AMERICAN FAIR TRADE COUNCIL—Annual Open Forum, Hotel Roosevelt, New York, N. Y.

November 17

TRADE ASSOCIATION TECHNICAL CONFERENCE — Symposium, Technology Center, Chicago, Ill.

November 18-20

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AND INSTITUTE OF RADIO ENGINEERS—Electronic Instrumentation in Nucleonics, Hotel New Yorker, New York, N. Y.

November 19-20

NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Annual Conference, Western Region, Biltmore Hotel, Los Angeles, Calif.

November 23-24

OPERATIONS RESEARCH SOCIETY OF AMERICA—Fall Meeting, Statler Hotel, Boston, Mass.

November 29-December 4

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting, Statler Hotel, New York, N. Y.

November 30-December 5

EXPOSITION OF CHEMICAL INDUSTRIES—Commercial Museum and Convention Hall, Philadelphia, Pa.

December 3-4

SOCIETY OF THE PLASTICS INDUSTRY—Film, Sheeting and Coated Fabrics Conference, Commodore Hotel, New York, N. Y.

December 8-10

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS — AIEE, ACM, and IRE Eastern Computer Conference, Statler Hotel, Washington, D. C.

January 11-15

SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Display, Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

Catalogs and Bulletins

Request additional information using postcards following page 224

(1) MOTOR-GENERATORS—The Electric Products Co., Bulletin 30-200, 6 pp. In describing motor-generators from ¾ to 1500 KW, it illustrates 23 designs of a-c to d-c, a-c to a-c, d-c to d-c, and d-c to a-c units. Electrical specifications and application of each design are given.

(2) STEEL TUBING PRODUCTS —Rochester Products, Booklet, 12 pp. Devoted to the use, fabrication and physical properties of small diameter steel tubing. Applications from flat-irons to automobiles and farm machinery are illustrated. Tables and data covering mechanical properties, diameters, tolerances, wall thicknesses and pressure tests for all single and double wall steel tubing.

(3) INDUSTRIAL V-BELTS—Durkee-Atwood Co., Catalog D-161 A, 60 pp. Contains much engineering data and tables on a line of industrial V-belts for multiple and general duty. Covers: belt types; calculations; comparison charts; correction factors; design information; drive tables; formulas; interchangeability selection charts; oil resisting belts; velocities; and other data.

(4) HYDRAULIC-PNEUMATIC OPERATOR — Allis-Chalmers Mfg. Co., Bulletin 71B7942, 6 pp. Describes the advantages of a new Pneu-Draulic operator for power circuit breakers, having the advantages of pneumatic and hydraulic principles. Has a typical rating table, and speed graphs, showing opening and closing of the mechanically trip-free oil circuit breakers.

(5) REINFORCED PLASTICS — The Dynakon Corp., Booklet, 12 pp. Data on laminates and moldings of

ELECTRO Dynamic

Extra dependable industrial motors

1 TO 250 HORSEPOWER (N.E.M.A. STANDARDS)

The WINDING is the HEART of the motor

1. *Extra insulation* in stator slots and between phases.
2. *Extra impregnations* and bakings of the wound stator.
3. *Extra high-frequency testing* of insulation between turns.
4. *Extra care* in fitting coils into stator.

QUALITY SINCE 1880

WRITE TODAY FOR NEW ILLUSTRATED CATALOGUE NO. 1160

One-piece cast iron frames.

Extra large "free-flo" air channels.

Permanently aligned cast iron brackets.

Liberal size grease lubricated bearings

Also a complete line of Direct Current motors and generators

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BAYONNE, NEW JERSEY

In this

MONARCH *of* DEFENSE

LEBANON Castings *are at work*

IN TANKS—those rumbling, roaring monarchs of our Ground Forces—vital points are protected with armor castings made by Lebanon Steel Foundry. For the Detroit Arsenal alone, Lebanon has produced over 60,000 armor castings—principally ventilating grille louvre doors and corner hull brackets for the M46, M47 and the current M48 medium (General Patton) tanks.

As early as 1935, Lebanon Steel Foundry cooperated with Army Ordnance in the development of cast armor. In 1952 Lebanon received a citation for designing and casting top-quality louvre doors for the medium tank. The engineering and production skills of Lebanon craftsmen have ably contributed to practically every tank development and production program since cast armor became a reality.

See—STEEL WITH A THOUSAND QUALITIES—37 min., 16 mm, semi-technical, full-color, sound film on the making of steel castings. For information write: Dept. C, Lebanon Steel Foundry.

LEBANON Castings

CARBON, SPECIAL ALLOY AND STAINLESS STEEL

LEBANON STEEL FOUNDRY LEBANON, PA.

synthetic materials having good electrical, chemical, mechanical and physical properties. All properties are given, along with fabrication, machining and cutting technique, plus sheet and rod sizes.

(6) FORCED FEED LUBRICATORS—Manzel Div., Catalog 25 G, 12 pp. Has all engineering data on several types of lubricators for all applications. Illustrations show units with variety of drives, and charts give capacities. Some models designed for service at up to 30,000 pounds.

(7) HIGH VACUUM PUMPS—F. J. Stokes Machine Co., Catalog 750, 36 pp. Includes tables of formulas, constants and conversions often used in vacuum processing; solutions to problems of pump selection for typical vacuum systems; and information on maintenance procedures. Has illustrations of all models, and includes complete specifications.

(8) PNEUMATIC CONTROL ACCESSORIES — Minneapolis - Honeywell Regulator Co., Catalog 8950, 16 pp. Describes, illustrates, and has specifications for a variety of accessories for pneumatic control applications. Includes: air pressure regulators; filters; pneumatic relays; control by-pass panels; pneumatic switches; valve positioners; and others. Has cross-sectional diagrams for each model, and piping diagrams.

(9) CONTROLLED VOLUME PUMPS—Milton Roy Co., Bulletin 553, 40 pp. Contains all information on the design and construction of a line of motor driven controlled volume pumps. Other data cover: capacity-pressure selection tables; types of capacity adjustments; standard and special designs; as well as packaged systems. A materials section chart and application chart are included.

(10) FLAW LOCATION—Turco Products, Inc., Bulletin A-500C 12 pp. Outlines the Dy-Chek method of locating flaws in metal parts. Tells how it is used, and illustrates use on the production line.

(11) MECHANICALLY SEALED PUMPS—Tuthill Pump Co., Catalog 101, 12 pp. Covers the complete line

Specify

GITS *Unit* SEAL

Result:

Economy

"Economy... counts not in savings but in selection."—*Edmund Burke*

Economy through Efficiency

Gits Unit Seal proves itself in dependable performance over a wide range of operating conditions—including extra-high speed, heat and pressure applications. Operation at peak efficiency always means dollars-and-cents savings.

Economy through Adaptability and Versatility

Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

Economy through Long Life

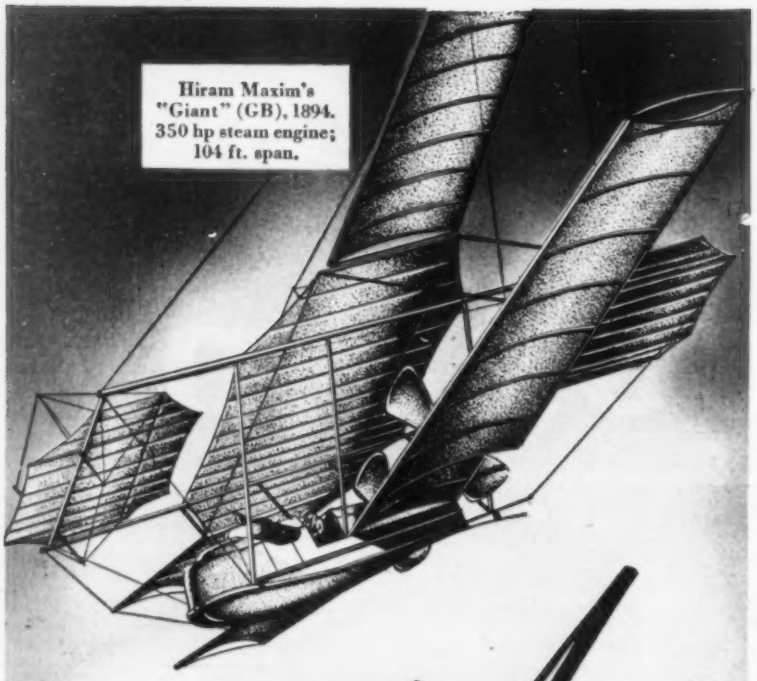
Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

Write Today For FREE Illustrated Brochure, or send us your seal problem. Our experienced engineering staff is at your service.

Cartridge Seal . . . requiring only 25% more space than lip-type seals.

GITS BROS. MFG. CO.

1838 S. Kilbourn Avenue — Chicago 23, Illinois



...out of this came Aviation

An industry whose tremendous growth has forced the continued expansion of the manufacturing facilities of many companies to feed this great industry's carnivorous appetite for production.

Indiana Gear Works is such a company—we began to produce precision parts for the aviation industry in 1933.

Today, twenty years later, we find ourselves continuing to increase our physical plant in order to gain the production capacity we need to consistently produce quality precision parts and assemblies.

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of the model L series pumps designed for lubricating, hydraulic, transfer, circulating, and burning oils service. Has many illustrations and engineering diagrams. A pump guide presents the services, operating data and other features for each model, to permit choice of the specific model.

(12) ELECTRIC CLUTCHES & COUPLINGS—Warner Electric Brake & Clutch Co., Booklet WEB 6089, 20 pp. Shows the electric clutch and the electric clutch-coupling, with cutaway drawings of each, plus photos showing applications of each. Also contains speed-torque and speed-heat charts to aid in selection, plus illustrations, dimensions, and specifications of each model.

(13) MEASURING EQUIPMENT—General Electric Co., Catalog GEC-1016A, 64 pp. Contains information on more than 115 testing and measuring devices for laboratory and production line use. Covers: electric circuit testing equipment; high voltage a-c and d-c equipment; insulation and resistance testing equipment; magnetic-field equipment; time switches and timers; materials testing and equipment; force and strain gages; and many others. Has complete descriptions and many illustrations.

(14) HARD FACING—Mir-O-Col Alloy Co., Booklet, 52 pp. A study of hard facing, its application, and wear-resisting qualities. A special section recommends specific hard facing rods for more than 1,000 pieces of equipment subject to impact and abrasion. Also discussed: effect of heat on metals; what metals can be hard faced; and other data.

(15) ROTARY COMPONENTS—Servo-Tek Products Co., Catalog 39, 38 pp. Has illustrations and brief descriptive data on line of rotary components. Some are: a-c series motors; d-c selsyns and step motors; 60 and 400 cycle servo motors; servo amplifiers; synchronous and timing motors; gyros; selsyns and synchros; motor and pump units; d-c gear reduced motors; d-c shunt motors; synchro capacitors; and many others.

(16) LIQUID COOLED COUPLINGS—Dynamatic Corp., Bulletin

WC-2, 12 pp. A detailed discussion of the application, characteristics, and construction of liquid cooled couplings. Gives data on: torque characteristics; applications; selection chart; basic construction; control; and methods of cooling.

(17) BRACKETS & SUPPORT CLAMPS—Thomas Associates, Catalog, 64 pp. Covers the complete line of 40,000 types and sizes of bare metal and cushioned line support clamps; wire harness clamps, and multiple support clamps. Has 114 detailed prints and complete specifications covering materials and finishes in aluminum, steel and stainless steel. Most clamps offered in a range of sizes from $\frac{1}{8}$ to 6 in. in increments of $\frac{1}{16}$ inch.

(18) INDUSTRIAL HYDRAULIC HINTS—Vickers, Inc., Bulletin 1300-S, 16 pp. Covers recommendations for hydraulic oil selection and basic hydraulic system maintenance on machine tools and other industrial machinery. A table of common hydraulic system difficulties and corrective action for each is included.

(19) LOCKNUTS—Security Locknut Corp., Bulletin, 8 pp. Illustrates a large variety of locknuts for every purpose for NC, NF, or special threads. Complete dimensions and specifications for all types of locknuts from $\frac{7}{16}$ up to 3 inches.

(20) INDUSTRIAL ADHESIVES AND COATINGS—Minnesota Mining & Mfg. Co., Booklet, 8 pp. A guide to the selection of industrial adhesives, coatings, and sealers arranged to permit the selection of the product best suited for the application. Illustrations show a variety of uses.

(21) CUTLESS RUBBER BEARINGS—Lucian Q. Moffitt, Inc., Catalog, 34 pp. Has engineering data on a special type of rubber bearing for use in pumps, agitators, and similar equipment where bearings can be lubricated with water, or by the liquid handled in the equipment. Has many illustrations, cross-sectional views, graphs, and charts.

(22) TRANSISTOR DATA—CBS-Hytron Co., Bulletin E-212, 8 pp. Completely illustrated, the manual is

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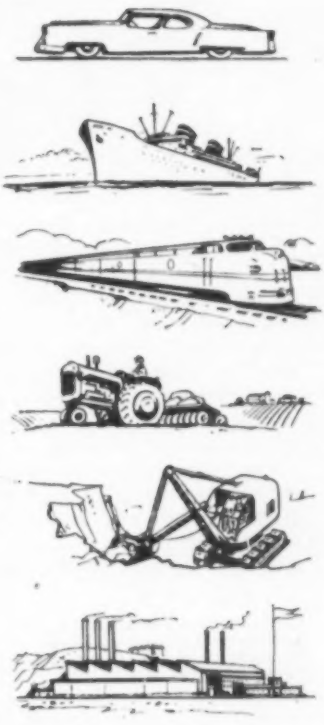

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divided into three parts: theory; data; and application. Included are 9 different basic transistor applications. Both point-contact and junction transistor operations are explained. Has many line drawings, graphs, application notes and specifications.

(23) INSTRUMENT BEARINGS—New Departure Div., Catalog, AIB, 28 pp. Deals with the classification, design and operating requirements of instrument bearings, and includes many examples of application to instruments. Descriptive details and dimensional data are included, plus many cutaway drawings.

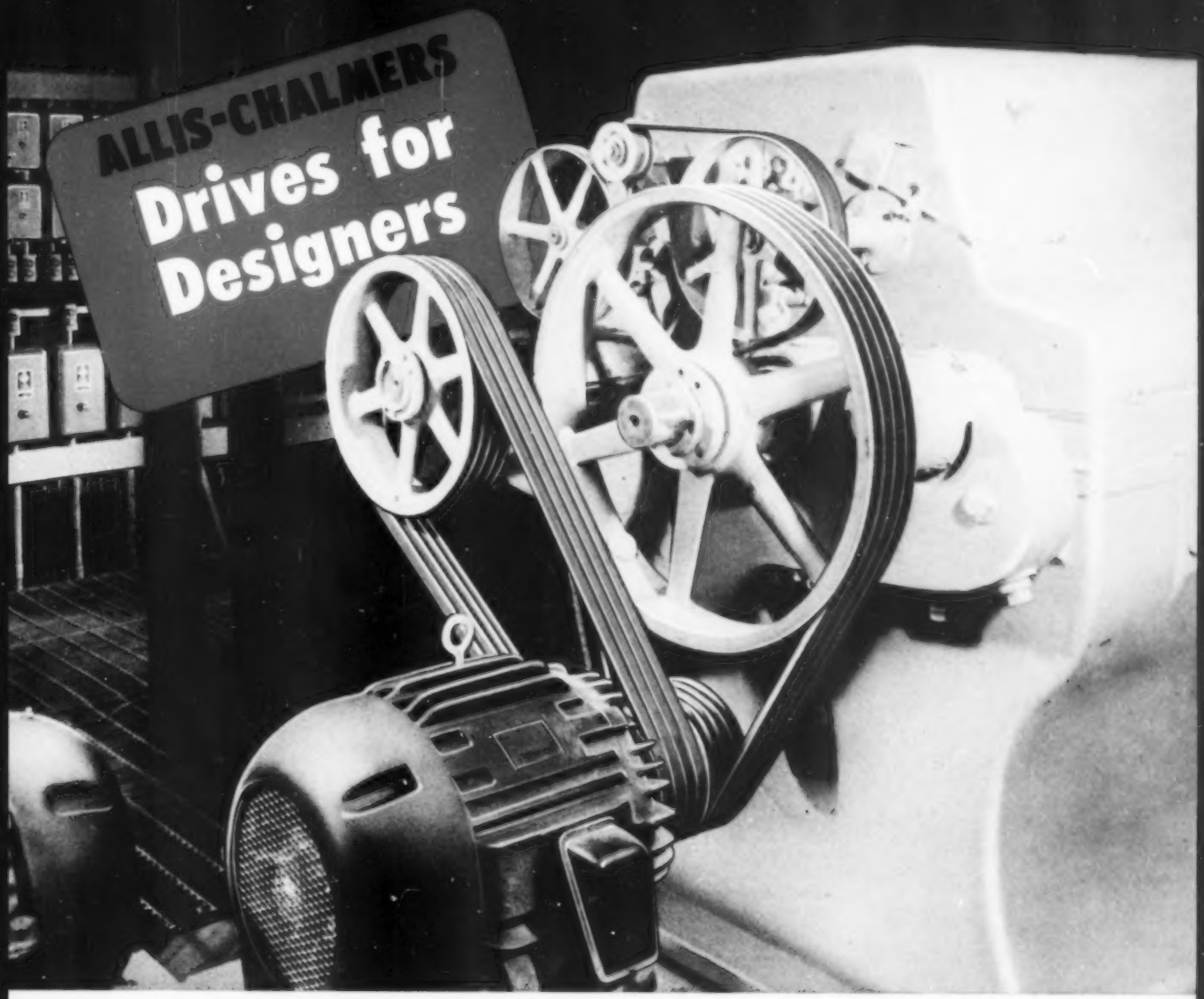
(24) ROTATING SHAFT SEALS—Cartriseal Corp., Booklet, 6 pp. Has engineering data and many cross-sectional views of installation of a new double-face cartridge seal especially designed for higher pressures, temperatures, and rpm.

(25) MECHANICAL SWITCHES—Delco-Remy, Bulletin 1S-100, 10 pp. Illustrations and data on a line of mechanical switches such as: ignition; lighting; headlight; panel lamp; foot selector; starting switches; testing manual starting switches; signal; and miscellaneous types. Has photos, cutaway, and schematic diagrams of the various types.

(26) MEASUREMENT INSTRUMENTS—Brush Electronics Co., Booklet, 34 pp. Illustrates and describes over 37 different instruments, designed for the following measurements: electrical; physical; resistance-welding; textile; electro-acoustical; ultrasonic energy applications; and others. Has complete data on all components. Fully illustrated.

(27) D-C MOTORS AND GENERATORS—The Louis Allis Co., Booklet, 16 pp. Covers a line of d-c motors from $\frac{1}{2}$ to 300 hp, and d-c generators from $\frac{3}{4}$ to 250 kw. D-c electrical characteristics are described, and d-c adjustable speed application data given, supplemented by circuit diagrams, and operating curves. All units are illustrated, and construction details for each are given.

(28) A-C MOTORS—The Howell Electric Motors Co., Catalog, 12 pp.



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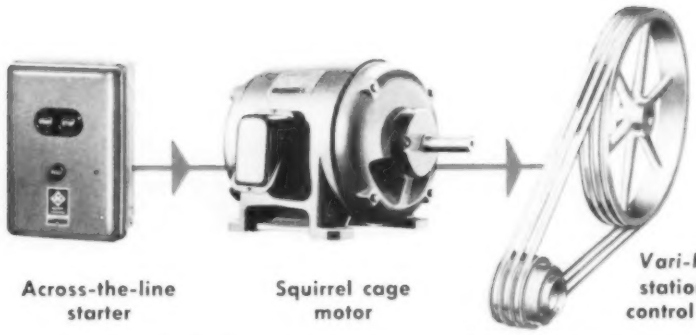
Economical variable speed for many applications where speed range required is not too great and where the machine may be stopped to make speed changes. Two *Vari-Pitch* sheaves used together double range of adjustment. Horsepower range — 1½ to 300. Speed adjustment range — 9 to 28 percent.



Across-the-line starter | Squirrel cage motor | *Vari-Pitch* stationary control drive

Mechanical

Popular for textile machinery and other machines where considerable speed adjustment is required. Available for either stationary or motion control. When both are *Vari-Pitch* sheaves, adjustment range is doubled. Horsepower range — 1½ to 40. Speed adjustment range — 2 to 1.

Combination starter | Squirrel cage motor | *Vari-Pitch* wide range drive

Electrical

Speed is varied by means of control on secondary windings of motor. Speed control by steps, but in larger sizes can be stepless type using liquid regulator. Horsepower range — 5 hp and up. Speed adjustment range 50% of synchronous speed to full synchronous.

Wound rotor control | Wound rotor motor | *Texrope* V-belt drive

Electrical

Motor is built in standard squirrel cage frame with special windings and control. Up to four speeds available from one motor. Furnished with variable torque, constant torque or constant horsepower. Horsepower range — ½ hp up.

Multi-speed motor starter | Multi-speed squirrel cage motor | *Texrope* V-belt drive

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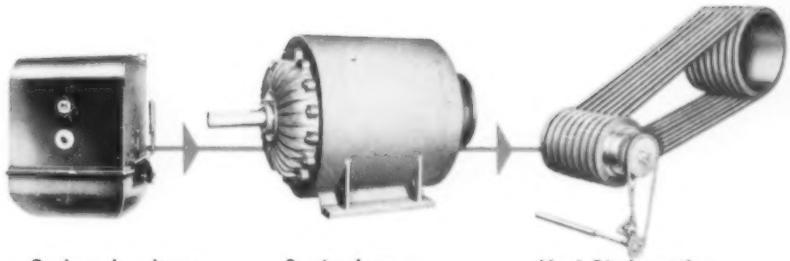
Speed may be changed while machine is in motion, particularly good for machines requiring fine adjustment while operating. Double range of adjustment may be obtained by using two sheaves. Horsepower range — 1½ to 300. Speed adjustment range — 9 to 28 percent.



Reduced voltage starter | Squirrel cage motor | *Vari-Pitch* motion control drive

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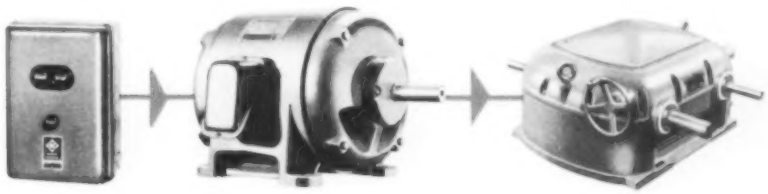
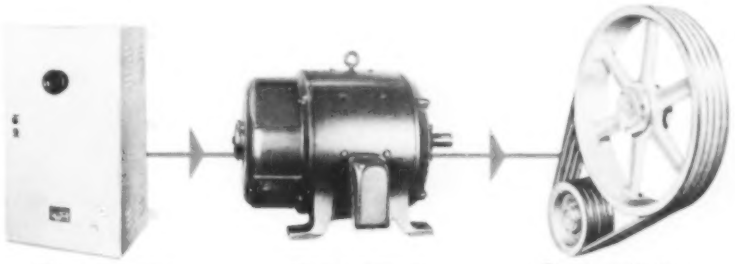
Enclosed unit with *Vari-Pitch* sheaves for speed control. For machines where extremely wide speed control is required. May be manually or remotely controlled. Motor may be mounted on speed changer housing for compact installation. Horsepower range — 1½ to 75. Speed adjustment range — 3¾ to 1.



Across-the-line starter | Squirrel cage motor | *Vari-Pitch* speed changer

Electrical

Speed is varied by means of various types of control. Available in shunt or compound wound for both constant and variable torque loads. Speed control may be stepped or stepless. Horsepower range—½ hp up. Speed adjustment range — zero to maximum speed. Maximum speed in smaller sizes, 3500 rpm.



Direct current control | Direct current motor | *Texrope* V-belt drive

Combination

For extremely wide range speed control, this combination drive combines the speed control range of the motor with that of the *Vari-Pitch* drive. Other combinations of electrical and mechanical variable speed can be worked out to fit the requirements of a particular design.

Wound rotor motor control | Wound rotor motor | *Vari-Pitch* wide range drive

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- ☐ Handy Guide to Motor Selection 51B6052
- ☐ Squirrel Cage Motors 51B6210

Control

- ☐ Across-the-line Starters 14B7132
- ☐ Reduced-voltage Starters 14B7215

***Texrope* Drives**

- ☐ Handy Guide to *Texrope* Drives 20B6051
- ☐ *Vari-Pitch* Drive Engineering Data 20B7499

Name..... Title..... Company.....

Address..... City and State.....

Has motor performance data, electrical and mechanical characteristics, construction features, and applications. Shows types of mountings, and various auxiliaries. Motors from $\frac{1}{6}$ to 500 hp.

(29) AIRCRAFT ELECTRIC MOTORS—U. S. Electrical Motors, Inc.. Bulletin 1535, 8 pp. Data on a range of motors from 1/20 to 16 hp. Motors described are the high frequency induction type 3-phase a-c used for controls in aircraft components. Many include built-in gearing and brakes in explosion-proof housings.

(30) HYDRAULIC HOSE ASSEMBLIES—Eastman Mfg. Co., Catalog 209, 46 pp. Well-illustrated with a variety of the types of assemblies available, complete engineering data and specifications included for: one wire braid hose and assemblies; two and three wire braid hose and assemblies; fabric braid hose and assemblies; spiral wire hose and assemblies; and straight and angled adapter unions.

(31) INDUCTION HEATING EQUIPMENT—Lepel High Frequency Labs., Inc., Bulletin, 38 pp. Schematic diagrams give the principles of induction heating, and its practical application. Has data and illustrations on heat treating for: surface hardening; annealing; differential treating; stress relieving; continuous heating; shrink fitting; melting; normalizing; bombarding; and treating thin parts. Illustrations and specifications on all equipment.

(32) GEARS, SPROCKETS, COUPLINGS—Perfection Gear Co., Catalog 360, 208 pp. Has complete data and illustrations of a line of: spur gears; spur gear rack; pinion wire; change gears and bushings; nonmetallic gears; internal gears; miter gears; spiral miter and bevel gears; spiral (helical) gears; worm gears; ladder chain sprockets; roller chain sprockets; flexible couplings; universal joints; and automotive gears.

(33) BRONZE BEARINGS—Johnson Bronze Co., Catalog, 104 pp. A complete listing of standard stock sleeve bearings, with illustrations and specifications of each type. Types covered are: general purpose; cast bronze graphited; electric motor serv-

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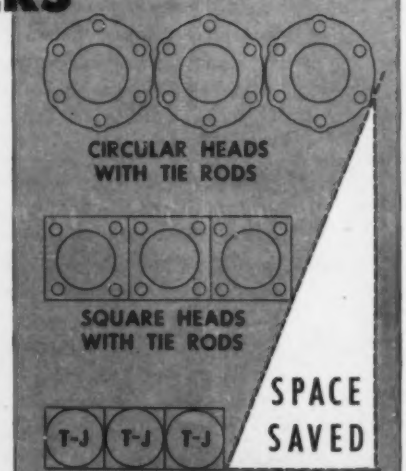
Available with the new T-J Super Cushion Flexible Seals which insure positive cushion with automatic valve action for fast return stroke. Many standard sizes and styles . . . for pushing, pulling, lifting, clamping or control jobs. T-J dependability. Write for bulletin 8152. The Tomkins-Jounson Co., Jackson, Mich.



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ice bearings; and self-lubricating. Also discussing oil grooving; flanged bearings and bushings; double-flange self-aligning and spherical self-aligning bearings; and plain cylindrical type. The last section is devoted to sleeve bearing design practice.

(34) HERMETIC TERMINALS—The Fusite Corp., Booklet, 20 pp. Describes a complete line of hermetically sealed glass-to-steel electrical feed through terminals. Ten different groups are described and drawn in detail. Included are: miniature singles; standard size singles; stand-offs; threaded bushing; multiples; plug-ins; and crystal can headers.

(35) DRAFTING MACHINES—Charles Bruning Co., Booklet A-2000, 20 pp. Presents a complete mechanical description of the various drafting machine models including gravity compensated, track type, civil engineering, and detail machines. Each part is shown in detail. The latest types of scales and styles of graduations available are also shown.

(36) VIBRATION ISOLATORS—The Barry Corp., Bulletin 534, 8 pp. A technical description of vibration isolators of the knitted-wire type. Performance data are given from measurements made under JAN conditions. Also has: line, and cross-sectional diagrams; specifications; and many operation curves.

(37) STAMPING MANUFACTURERS—Pressed Metal Institute, Catalog. 55 pp. Called "The Blue Book of Stamping Manufacturers," this directory lists the facilities and services of all member companies, and also a statement of policy to customers, subscribed to by all members.

(38) PACKAGED, ADJUSTABLE DRIVES—Westinghouse Electric Corp., Booklet B-5808, 16 pp. Complete information about packaged adjustable-voltage drives for variable speed application. Discusses: construction and operation; typical applications; and the economics of operation. Characteristics that can be added are: inching; reversing; dynamic braking; and multi-motor control are described.

(39) FASTENINGS OF HIGH TEMPERATURE ALLOYS—H. M.

Harper Co. Bulletin HTA, 16 pp. Data on high temperature alloys such as Refractaloy; Discaloy; Inconel; Hastelloy alloys; A-286; stainless steels; and a special section on Titanium. Also has a section on the characteristics of high temperature bolting. Tables give mechanical properties and chemical composition, and illustrate types of fastenings produced from super alloys and titanium.

(40) MINIATURE BALL BEARINGS—Miniature Precision Bearings, Inc., Catalog, 20 pp. Comprehensive design and application data on miniature ball bearings in sizes from 0.100 in. OD to 0.375 in. OD. Covers: radial; angular contact; pivot; and thrust bearings. Each bearing is illustrated, has cutaway views, a low-speed chart, and other specifications. Has section on design factors involving miniature bearings.

(41) HIGH PRESSURE SOLENOID VALVES—Waterman Engineering Co., Booklet, 24 pp. Complete engineering data on a line of high-pressure solenoid valves capable of continuous operation at pressures to 3,000 psi, for hydraulic systems handling noncorrosive fluids. Has illustrations and piping diagrams using each type; all available for a-c and d-c operation. Also has sections on: automatic flow regulators; adjustable flow regulators; and check valves.

(42) CONTROL VALVES—Valvair Corp., Bulletin SK-53, 8 pp. Has complete engineering data and specifications for all models of a line of solenoid pilot operated control valves for control of air or low pressure hydraulic operations. Speed is up to 600 cycles per min for air service. Also includes illustrations of all three and four way types.

(43) HEAVY-DUTY ENGINES—Wisconsin Motor Corp., Catalog S-150, 64 pp. Has a total of 263 photos plus other engineering cutaway views of a complete line of heavy-duty air-cooled engines. Also has performance curves of all models. Single cylinder models from 3 to 9 hp; 2 cylinder engines from 7 to 15 hp; and 4 cylinder engines from 15 to 36 hp. Complete specifications are given for each type. Photographs illustrating some of the applications of the various models are included.

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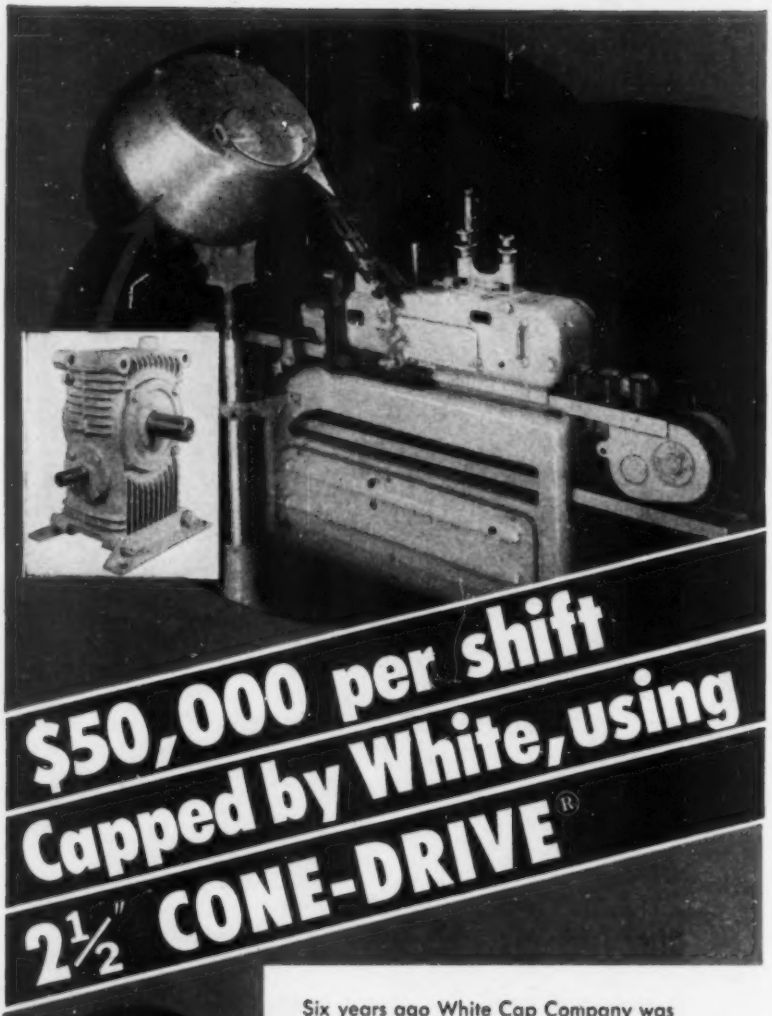

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White Cap found the answer in a standard 2½" C.D. Cone-Drive speed reducer. Over 500 of these machines—operating under lease—have proven it.

The reducer had to be efficient since it is totally shrouded. Driving a 22" disc which feeds caps to the sealer for $50,000 or more worth of product per shift, it has to be ultra-reliable and have a high bearing load capacity. Space is limited under the disc (the reducer measures only 10¾" x 6¾" x 5⅛"). Weight must be low (it weighs 43 lbs. net).

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Sans, Souci

Ad Libbing by the Editor

A vice president of one of the country's largest corporations was discussing opportunities for advancement in his organization.

"It is not true," said he, "that just because a man is a little better than his boss he gets the boss's job. There are many men pushing pencils in this company today who could do my job just about as well as I am doing it. But if this company were to attempt to promote immediately every man who seems to be able to do his boss's job a little better, we would be spending all of our time organizing and reorganizing and never get any work done. On top of that there would be many mistakes made in promoting the men because it is often mostly a matter of opinion as to whether or not the subordinate can do the boss's job better.

"The subordinate has to be able to do the job a great deal better than his boss and his boss has to be below average in order to make the gap between the abilities so big that there can be no question as to who can do the job better. And even under such conditions the subordinate usually must wait awhile before his promotion can come through. Few men will willingly work for a company that ruthlessly hires and fires and demotes in a vain attempt "to put the best man in the best job." Such a company soon finds that its employees have become totally demoralized by the uncertainty of their job.

Putting an Idea Across

Most people will not listen thoughtfully and without prejudice when someone is trying to present to them a new idea. They listen with their ears only, while their mind is dreaming up objections and deficiencies. Egotists are more likely to be victims of that shortcoming by virtue of the fact that they have little patience for learning new ideas.

One of my good friends of many years standing was chief engineer of a company manufacturing home appliances. Quite a few years ago he got some wonderful ideas about a new design of electric flat iron. He ex-

plained it to the sales manager who immediately had innumerable objections. He showed it to his boss who was extremely impressed by the sales manager's judgment and paid little attention to the chief engineer's description and sales talk.

Finding it impossible to get any of these men to give him the time and effort to really understand what he was offering, the chief engineer made a full-scale working model of the design of iron he had in mind. He did it by resorting to a lot of trickery and a lot of connivance in the model shop. When it came to the next annual company salesmen's meeting he asked permission to talk to the salesmen and was patronizingly told that he would be given that opportunity.

When the opportunity came, this chief engineer walked on to the platform carrying his sample of his new design of electric iron. He gave a dramatic demonstration of its wonderful qualities, its lightness, its temperature control and its construction features. He put on a terrific sales talk and ended up with, "Gentlemen, that will be the iron you will sell next year."

The chief engineer staked his whole job and future on the success of his sales talk at this annual meeting. Fortunately for him he gave the men an excellent talk and they howled with enthusiasm and wanted to know when the company would be in production on the new design of iron. The sales manager's face went red, the vice presidents were terrifically angered. They threatened to fire the chief engineer. But when the smoke of battle cleared, the company had launched a program for manufacturing the new design of iron which the chief engineer had developed.

As an epilogue to the story, that friend of mine is now vice president in charge of engineering in a competing company. He has a swell job. He gives his men the kind of a deal he should have gotten in his old job. He is a great success. He is getting a continuing flood of new ideas from his men, and they get rewards for them.

One can "go places" on the open road. Similarly, a company with open minded management "goes places." The word "no" contains only two letters and can be spoken more emphatically and quickly than the word "yes,"

Constant extracting with 18 standard CONE-DRIVE® units

Month-after-month operation under continuous load is a grueling measure-of-quality for any type of gearing. Cone-Drive gears can take it.

Knowing this, The Vulcan Copper and Supply Company specified Cone-Drive double-enveloping worm-gear speed reducers to turn the rotating impellers of their "Kennedy" Counter-Current Solvent Extractor.

Impellers are turned continuously by 18 **standard** 2½" center distance 50/1 Cone-Drive speed reducers. Worm speed is 6 rpm and output torque is 900 inch-pounds.

Other factors that make Cone-Drive gears a 'natural' for chemical processing drives are: (1) compactness, (2) resistance to shock loads, (3) high load-carrying capacity, (4) minimum maintenance costs and (5) delivery as off-the-shelf units.

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which has three letters. But the negative has never created anything. It is far more constructive for a management to assume that the idea is sound and then study it critically, first to understand it fully and only secondly with the idea of ferreting out its shortcomings, if it has any. The opposite approach means stagnation. Because, if the idea is accepted as being wholly wrong, it will not be studied to see if there is anything right about it. It will never be accepted.

Often an individual bemoans the fact that his wonderful ideas are not considered by management. The solution to such a problem is not to permit the mind to dwell upon what it considers injustice but rather to concentrate on finding ways and means by which other people might be induced to agree. Few people have time to listen to the individual who makes sweeping claims and derides others because they don't agree with him. He has a chip on his shoulder and becomes obnoxious to everybody. There is always the possibility of finding some way of putting the idea across, just as did the fellow who designed the new electric flat iron and is now vice president in charge of engineering.

Assumptions Versus Facts

Often it is merely assumed that a certain individual possesses superior abilities and qualifications. The basis for such assumptions may be a pleasing personality, ability as a glib talker.

It is amazing how many of our decisions are made upon assumptions that have absolutely no basis in fact. I am reminded of Dr. W. R. Whitney, that wonderful scientist who founded the General Electric Research Laboratories and who was in charge of those laboratories for many years. I was sitting in his office one day and he began telling me about a walk that he had taken along the seashore. I have forgotten some of the unimportant details, but in substance, this is what he said:

"I am always attracted by the beauty of sea shells. They have a pearl-like lustre and every shell is different. I gathered a few especially interesting shells in my walk along the shore two weeks ago and I started to think about their chemical composition. The natural conclusion would be that the sea shells are largely calcium. And as

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Sans, Souci ..... continued

I played with one of those shells, I suddenly realized that I was assuming that the shell was largely calcium in the form of calcium carbonate. Then I began to search in my mind for a basis on which I might have drawn that conclusion and I realized that I had simply jumped to the conclusion and that the conclusion in fact was nothing more than an unsupported assumption. I decided to put the shell to the test so I put it in a beaker filled with acid that would dissolve calcium carbonate.

"There on that shelf," said Dr. Whitney, pointing to it, "is the shell in its beaker. It still looks exactly the same as when I put it in there. I was totally wrong." Then Dr. Whitney talked about the mistakes we make by assuming that conclusions are facts.

It is only too easy for the human mind to jump to conclusions and make assumptions. The mind demands explanations for any and every phenomena and is impelled to make assumptions that will explain questions and answer problems. In fact, the natural mental procedure is to make an assumption and then gather facts, fancies and interpretations that will finally establish a proof of the assumption. At least, a "proof" that is satisfactory to the mind of the individual.

This is perhaps the greatest pitfall there is. There is a tremendous temptation for the mind to interpret any event in such a manner that it will substantiate a prior assumption. If a new political party comes into power there are always many who will predict disaster in some form or another. The most common form of disaster is a depression. So intent will those minds be set upon having an economic depression after the new party takes power that any and every event will be interpreted as a sign that the depression has arrived. In fact, the event may have not the remotest relation to the economic condition of the nation, yet the depressionist will hail the event as proof positive of his prophecy.

In our engineering design work we face the ever present danger of making assumptions in order to prove our point or making assumptions which we call facts and proving them by warping subsequent facts, data or thinking.

Years ago I was in a shop where we were building the prototype of a small turbo generator unit. The shaft of the turbo generator had two bear-

ings with the turbine wheel overhung on one end and the generator rotor overhung on the other end of the shaft. One of the engineers was extremely critical of everything the designer of the machine had done. Even before the machine was assembled, this critic loudly proclaimed that it would be impossible for the shaft to run true because of the deflection caused by the over-hanging load on each end. This critic was extremely gleeful when it was found that the commutator on the armature ran out more than 20 thousandths of an inch.

"Just as I expected," yelled the critic, "Any good designer knows that you cannot over hang a load like that and expect the shaft to run true."

Then there followed a long discussion on what constitutes good design for a small turbo generator unit.

As proved by later events, the original design was good. In fact, I thought it was very good and I always admired Mr. Darling, the designer, for having turned out a very fine compact, strong machine. When we found the commutator running out, the next step was to discover what caused it to run out. We took the armature off and, lo and behold, the shaft was running true. We checked the tapered armature spider and the ground taper on the shaft and both seemed to be perfect. The critic was in great ecstacy. "What else did you expect?" he cried. "It is the deflection of the shaft when the weight of the armature gets on it that causes the run out. The shaft simply bends and warps the armature around."

It didn't taken Mr. Darling long to show by computation that the deflection of the shaft was absolutely negligible. It was finally discovered that a spring washer against which the inner end of the armature bore, was the cause of the run-out. When this manufacturing defect was rectified the machine ran beautifully. And for many, many years those turbo generators did wonderful service on many steam locomotives. The moral of this lesson is that the critic had made an assumption and then interpreted every subsequent phenomena as proving his assumption.

The quaint expression is "The wish is father to the thought." Likewise, the wish is the father to the proof of the correctness of a wrong assumption. —G.F.N.

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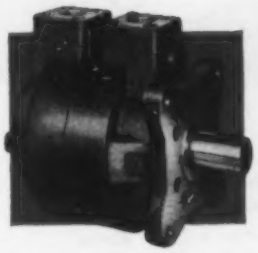

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ENGINEERING ABSTRACTS

High Temperature Properties of Glass Fiber Phenolic Laminates

Abstracted from "The Trend of Complete Aircraft and Guided-Missile Structures Toward Reinforced Plastics" by William E. Braham, Zenith Plastics Company. *Aeronautical Engineering Review*, September 1953.

THE EFFECTS OF elevated temperatures on the metal alloys used in aircraft primary structures are well known and are recognized as detrimental to the efficiency and safety of the aircraft or guided missile. Improvements in these metals are required, or new materials usable for primary structures must be developed.

In the development of materials that would be suitable for primary aircraft structures and guided missiles—particularly those operating above the speed of sound—reinforced plastics (glass fibers impregnated and laminated with synthetic resins) have become an important factor. Some of the test results achieved with these materials, Figs. 1-3, have been compared with metals that have been accepted and used in the construction of aircraft and guided missiles. In Fig. 1, data illustrate the specific ultimate tensile strength—ultimate tensile stress divided by specific gravity—of seven sheet materials and the variation of this property with temperature. By use of specific strength and moduli of elasticity, materials can be compared on an equal basis.

The data shown for the reinforced

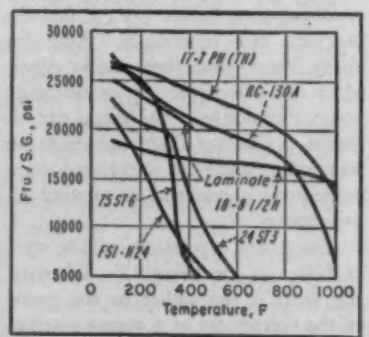

Fig. 1—Specific Ultimate Tensile Strength

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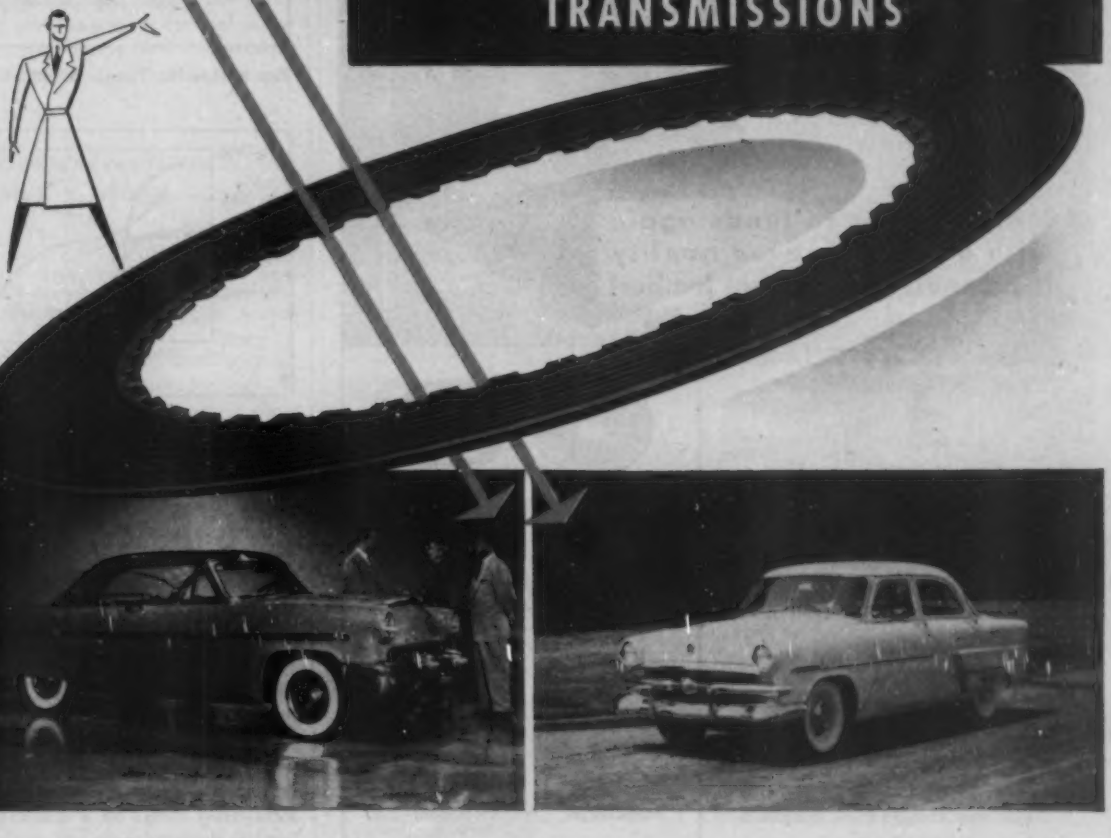

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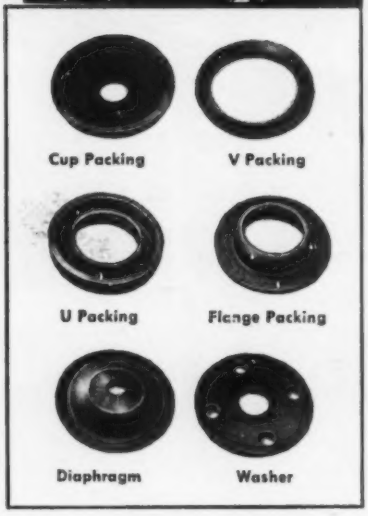

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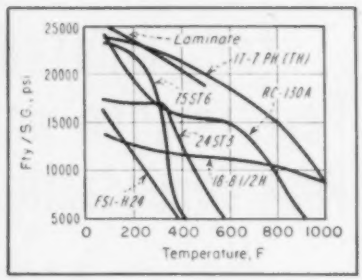


Fig. 2—Specific Tensile Yield Stress

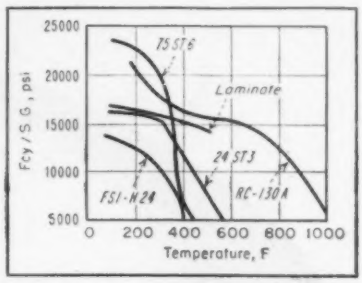


Fig. 3—Specific Compressive Yield Strength

plastic materials are for glass fiber phenolic laminates. A review of these data, obtained from sheet stock exposed ½ to 2 hr, reveals that the strength properties of aluminum and magnesium sheet alloys fall off rapidly above 300 F. The most promising materials for use above 300 F appear to be titanium, stainless steel, and glass fiber phenolic laminate. In sheets of equal weight, glass fiber phenolic laminates compare favorably with metal-alloy sheets on a stiffness basis, but the shear strength and modulus of the glass fiber phenolic laminates are poorer than the metals. However, because of the inherent ease of constructing glass fiber sandwich components, this characteristic can be overcome.

Many advantages have been found in the use of reinforced plastic materials for high-performance aircraft and guided missiles. These materials are less expensive to mold than metals, and more easily produced in tapered thickness for aircraft structures. They are easier to service and maintain in the field, and are resistant to the corrosive effects of sea water, high humidities, aircraft fuels, hydraulic fluids, lubricating oils, and air at high temperatures. The tapered thicknesses that are required in most modern aircraft wings and tail surfaces can be produced from reinforced plas-

tic materials with semi-skilled labor and inexpensive equipment. Molds and tools for forming the aircraft structures are less costly than equivalent tooling required to form metals. Less space and fewer complex assemblies are needed to produce a reinforced plastic structure, because component plastic parts can be easily bonded to their parent material under almost any atmospheric conditions, without the use of special equipment.

Dimensional Tolerances For Steel Castings

Abstracted from "Dimensional Tolerances for Steel Castings" by Charles W. Briggs, Technical and Research Director, Steel Founders' Society of America, Cleveland, Ohio. *Mechanical Engineering*, August, 1953.

SPECIFICATIONS for structural and engineering grades of steel castings are based, primarily, on mechanical property minimums rather than on chemical limitations, such as the SAE and AISI series of steels. The customer indicates what properties he desires, and the steel foundry uses the best combination of chemical elements that, in its opinion and experience, will produce the properties required.

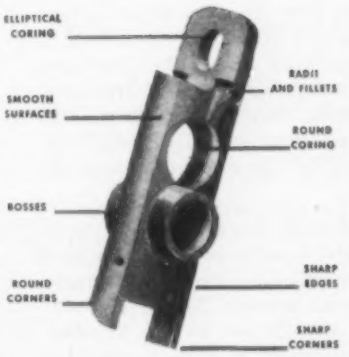
In some cases, purchasers of steel castings construct—or have constructed for them—the pattern equipment of a part. However, prior to submitting the pattern to the steel foundry, it is believed advisable that information on pattern construction should be presented.

Patternmaker's Shrinkage Tolerances. The contraction effect, which accompanies solidification, is compensated for by making the pattern larger by the amount of shrinkage characteristic of the metal used, the casting design and mold construction.

The molding methods employed by two foundries may be so different that entirely different shrinkage allowances would be required for the same pattern. Also, the casting design may be such that, because of hindered contraction, it is possible to have several different shrinkage allowances in one pattern.

Patternmaker's shrinkage is usually reported in fractions of an inch per foot; therefore, shrinkage values vary from $\frac{5}{32}$ to $\frac{1}{16}$ in. per ft.

The figure often used is $\frac{3}{16}$ in. per



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ft, but its universal adoption would lead to trouble and errors in casting dimensions and tolerances.

Draft. The amount of draft depends upon the size of the casting, the method of production, and whether molding will be by hand or machine. Machine molding requires a minimum amount of draft. In green-sand molding, interior surfaces usually require more draft than exterior surfaces. Under normal conditions, the amount of draft recommended is not less than one deg, or approximately $\frac{1}{16}$ in. per ft. This allowance normally would be added to design dimensions, but an effort should be made to maintain metal thickness.

Castability

Minimum Section Thickness. The rigidity of a section often governs the minimum thickness to which a section can be designed. There are times, however, when a very thin section will suffice, depending on strength and rigidity calculation.

Metal cools as it runs in a section through a mold. Thus, a thin section close to the gate that delivers the hot metal will run; the same thin section at a distance from the gate may not run. Since the design engineer has no knowledge of the location of the gate, a minimum thickness of $\frac{1}{4}$ in. must be suggested for design use.

It should be pointed out that steel flows best for a given thickness in a narrow, rather than in a wide, web. If the $\frac{1}{4}$ in.-thick section is longer than

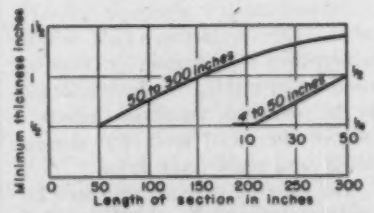

Fig. 1—Minimum thickness of sections as a function of their largest dimension.

12 in., then the minimum thickness should be increased in accordance with the values in Fig. 1. This chart represents the best of design conditions, wherein molten steel enters at one position on the casting and must run the lengths prescribed on the chart. Provisions may be made by the foundryman, through the application of special techniques, to pour even longer

members through thinner sections than indicated by the graph.

Casting Dimensional Tolerances

Casting Finish Tolerances. Casting dimensional tolerances are closely aligned with patternmaker's shrinkage and the hindering of the contraction of steel castings through mold and casting resistance. Studies on free and hindered contraction can guide engineers concerning those tolerances that may be expected on steel castings that are not machined. The tolerance values have been based on the longest dimension of the casting. It is realized that length is not the controlling factor; nevertheless, the use of the largest dimension is a convenient value for ready use to the engineer.

If it is remembered that the tolerance may vary, depending on the type of hindered contraction encountered, then Table I on dimensional tolerances will be useful.

It is suggested that the average value be used, and in no case should a value below the minimum be used. The concise value is one that could be employed on casting designs that have been made by the foundry, and, because of their experience with this particular casting design, a concise value can be met and maintained.

Section Thickness Tolerances. Steel castings that incorporate low factors of safety, and are critically designed for maximum-strength weight-saving structures, may have specified restrictions regarding certain or all casting sections of the part. This tolerance is ± 5 percent of the casting section for castings having sections up to 2 in. The section thickness tolerance is ± 10 percent in sections greater than 2 in., or large heavy castings.

Weight Limitations. Tolerances for weight limitations are specified only on castings that have been cast previously and for which a weight has

Table I—Dimensional Tolerances for Steel Castings Not to be Machined

Tolerance	Between 12 and 36 in.
Average	$0.06 + 0.006D$
Concise	$0.05 + 0.005D$
Minimum	$0.04 + 0.004D$

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parts: small connecting rods

alloy: "600" series metal, a high strength bearing bronze that contains no tin

quantity to date: over 2,000,000

number of failures: none

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advantages: no bearing insert is necessary on either the wrist pin or crankshaft end because each rod acts as its own bearing. Dense homogeneous grain structure, close dimensional tolerances and high mechanical properties often permit redesigning for weight savings as high as 15% to 25%. "600" alloys have low coefficient of friction, high resistance to corrosion and tensile strength 2½ times greater than cast phosphor bronzes.

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"600" SERIES ROD is produced in standard 12-ft. mill lengths and a wide range of sizes and special shapes. This rod has a fine, uniform grain structure and the mechanical properties are rigidly controlled in the cold drawing process. Scrap loss is greatly reduced in machining operations because of the complete absence of defects. For complete information, write us today.

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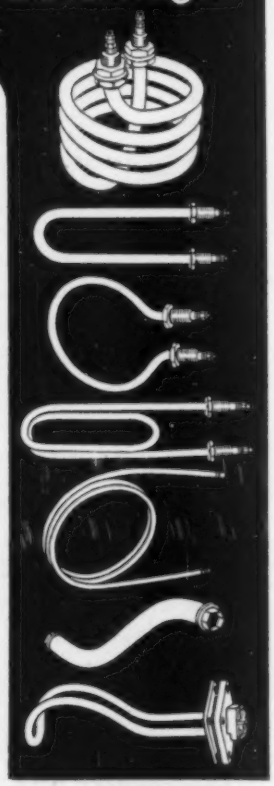

GREATER STRENGTH is offered by Avon's new Fusionweld process because of the complete uniformity of grain structure found throughout the entire tube wall, including the highly critical welded area. This feature eliminates the need for bonding with another metal, also eliminates the internal stresses resulting from variables in expansion coefficients where rapid temperature changes are involved. Fusionweld thin-wall steel tubing now can be employed as a satisfactory, low cost substitute in most electro-thermal tubing applications with absolute confidence in the end results.

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Table II—Guide to Machine-Finish Tolerances

Rings, spoked wheels, spoked gears, circular-shaped castings

Casting Diameter in.	Allowance on outside radius, in.
Up to 18	1/4
18 to 36	5/16
36 to 48	3/8
48 to 72	1/2
72 to 108	5/8
108 and up	3/4

Bores

Bore Diameter in.	Allowance on bore radius, in.
Up to 1	Cast solid
2 to 7	1/4
7 to 12	3/8
12 to 20	1/2

been established. The reason for this is that estimated weights are often at considerable variance with actual weights. After the weight has been established on a particular casting, this weight will not vary by ±10 percent.

Machine-Finish Tolerances. The tolerance to be added to the casting section for machining purposes will depend entirely on the design of the casting. For example, a ring gear may require a greater machine-finish tolerance than a spoked gear.

Again, definite values of machine-finish tolerance cannot be established for all casting designs, but guides can be suggested to designers. Such guides have been prepared and are presented in Table II.

Location Points. Locations to be used by the machine shop are important items frequently neglected until the casting is made. When possible, they should be indicated on the drawing, so that castings may be checked satisfactorily, always from the same reference point, by the pattern shop, the foundry, and the machine shop. An effort should be made to place them on the same side of the parting line. They should be situated so that they will not be influenced by a shift of a core, the cope, or the drag. The points should be as far apart as the

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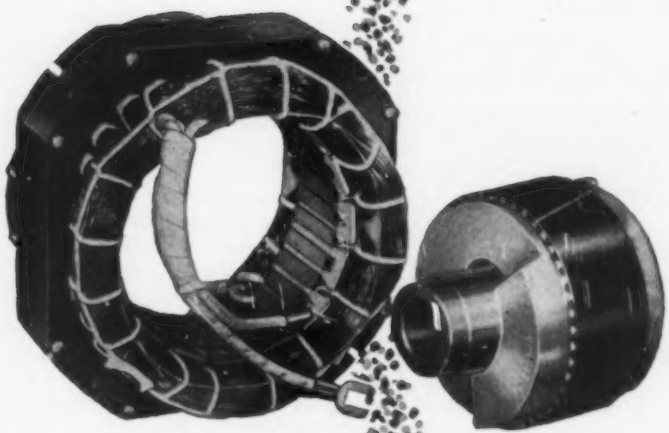

You can benefit from Emerson-Electric's 63 years of experience in motor design and production. If you have requirements in ratings from 1/20 to 5 h.p., or hermetic motors from ⅛ to 20 h.p., Emerson-Electric has the right motor for you. Your inquiry is invited.

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- ☐ 449-G Blower

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size of the casting permits, as this will insure the most accurate results. Dimensions, which have no finish allowances and are held to close limits, should be considered as the proper place from which to start development of tooling fixtures.

Design Factors for Torque Converter Oil Coolers

Abstracted from "The Development and Application of Oil Coolers for Torque Converters," by R. P. McDonough, General Motors Corp., Harrison Radiator Div., Presented at SAE National Tractor Meeting, Milwaukee, Wisc. September 14-17, 1953.

THE INCREASED USE OF torque converters has brought about the problem of designing compact, high performance heat exchangers. Because of element slippage within the converter, heat developed from the power loss has contributed to the problem of seal maintenance and oil breakdown. To keep oil temperature down to a reasonable level, certain design factors must be considered to determine the size of the cooler required.

The first design factor is to determine the type of transmission oil cooler most convenient to use. If direct oil cooling is selected, it must be decided at what maximum ambient air temperature the equipment is to be operated. And included in this analysis must be the allowance for heat pick-up from the surroundings. If a radiator-water-cooled system is chosen, the maximum allowable water temperature must be known. In the latter case, the radiator design is affected, since the transmission oil and the engine heat loads are additive, thereby increasing the size of the radiator needed.

The second design factor is the maximum oil temperature at the extreme condition. This temperature also must be considered in its effect on surrounding equipment and on personnel space. About 300 F is considered a reasonable maximum at the most severe cooling conditions.

A third item for consideration is the rate of flow of the oil and that of the radiator water, if it is used for cooling. Flow rates and system pressures must be determined in designing the circulating pumps. Similarly, the water pump capacity should be com-

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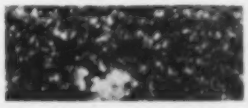
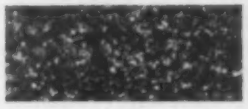
Cross-section of average compound



Coarser, less dense pattern of rubber is indicated in this photomicrograph of a standard packing compound, magnified 240 diameters. Note lack of uniformity.

Cross-section of Vix-Syn compound



Fine-grain density of rubber throughout Houghton Vix-Syn Packing is shown in this cross-section similarly magnified. This compact, homogeneous quality means longer packing life.

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mensurate with the allowable temperature gradients through the engine and with the system pressure losses. Where cooling water is not available, a fan or blower of adequate capacity must be selected. To evaluate air horsepower requirements, it is usually wise to plan on a mass air flow rate two to three times as great as the oil flow rate and at a static head of from three to six inches of water. This factor adds to an increased power demand on the engine.

The fourth factor is the maximum heat loss rate in the converter. Since the heat loss increases with the torque ratio, it is impractical to design a cooler for the stall condition. The usual design is for steady-state operation with peak loads dissipated over subsequent short periods. But extended periods of moderately high torque conditions must also be considered, such as in tractor and earth-moving operations. The more frequent and sustained these periods are, the larger is the heat exchanger required.

In conjunction with the thermodynamic considerations, installation space is also important. Generally, the cooler should be as small as possible, avoid excessive weight, and minimize the total amount of oil required in the system. Best location of the cooler should also be considered. Overall requirement is to place the cooler adjacent to the transmission housing to keep the oil lines reasonably short.

Since heat transfer rates from a metal wall at one temperature to an oil or air stream at another temperature are low (in comparison with other common heat transfer mediums), the surface area of the wall in contact with the oil must be increased. This is accomplished by folding the metal back on itself or by fastening fins to its surface. The conductance rate can also be increased by artificially inducing turbulence in the fluid stream with sharp-edged obstructions. Both changes or compensations can be made at the same time. However, pumping power required will probably increase, but if velocities are kept low, the increase can be minimized. On the cooling air side, air flow requirements can be reduced by increasing the heat transfer surface with small increases in weight and size. Since the transfer rates on the water side of coolers are high (compared to oil or air), in-

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SINCE steel is a ductile material, it withstands shock loads without fracture. As a result, to eliminate shock failures, machine components can be simply changed to welded steel construction. At the same time, manufacture is made simpler, material cost is less, and fewer manhours are needed for production to cut costs an average of 50%.

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In the examples shown, breakage in the flipper assembly created service problems for this company. Because of limited clearance, it was impossible to increase wall sections.

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By converting to welded steel construction, the manufacturer was able to eliminate breakage completely, yet cut his cost from $4.50 to $1.00 per unit. The one and one half pounds less metal now needed actually produces a stronger, more rigid assembly than possible before. The entire unit is produced in the shop without waiting for outside sources. With less machining and less cleaning, fewer manhours are required to turn out a more dependable product.

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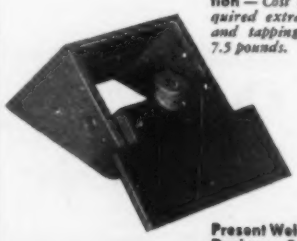

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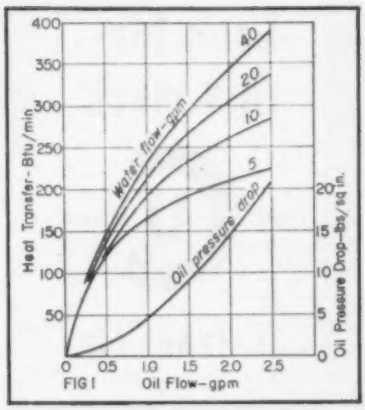

FIG 1

creased surface or induced turbulence are not generally considered.

Materials used in developing heat exchanger designs consist of steel, aluminum, copper and copper-nickel alloys. Aluminum finds application where weight is a primary consideration and a better heat transfer surface is required. Copper-based metals are used where corrosion is a serious factor. But generally, steel has been used because of its reasonable cost.

As a result of all the design considerations, heat transfer and fluid friction test data on a dimensionless correlation and overall basis have been obtained, making it possible to calculate oil cooler size required for any given set of conditions. Fig. 1 shows the heat rejection characterisitcs of the single plate cooler as a function of oil and water flow rates. Oil inlet temperature is 280 F, water inlet temperature, 160 F. Plate size is 3 x 7 in., and SAE 10 oil is used in the test. The chart was plotted from data obtained under controlled laboratory con-

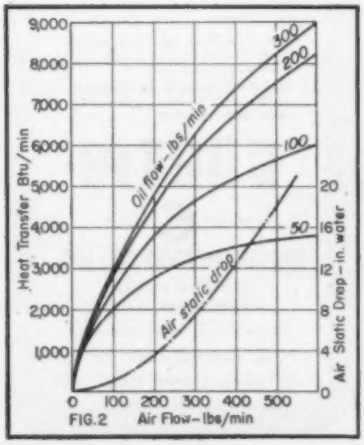

FIG.2

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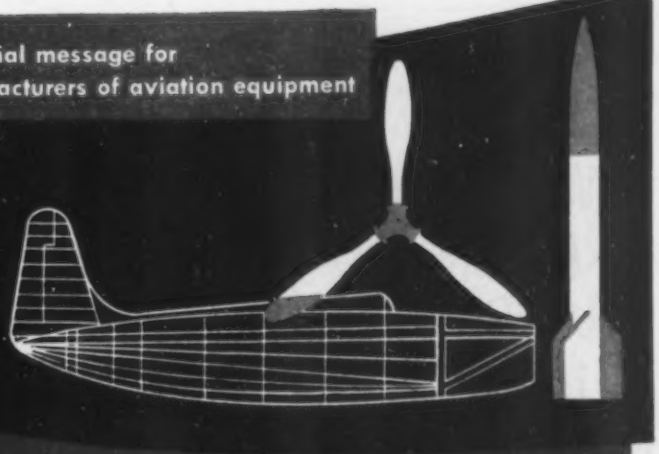

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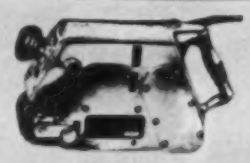

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ditions and later substantiated through a series road tests.

Fig. 2 shows the heat transfer characteristics of a twenty-two plate aluminum cooler that uses air as the cooling medium. Plates are 3 in. deep by 22 in. long. Air inlet temperature is 100 F, oil inlet temperature —275 F. Oil used was SAE 10 grade. Heat transferred in Btu per min is plotted as a function of air flow for various oil flow rates. Air flow pressure loss is also given in terms of static pressure drop in inches of water, corrected to standard density. From the curve, air horsepower requirements can be determined. It is important to realize that with air cooled oil coolers, the heat transfer rate is very sensitive to air flow, while in water cooled oil coolers, the volume of air flow is usually more than adequtae for cooling.

Improvements In Transistors

Abstracted from "Are Better Transistors At Hand?" *Aviation Week*, September 14, 1953, p 76.

IN A TALK given before the recent Western Electronics Conference in San Francisco, Donald G. Fink, director of research for the Philco Corporation, stated that developments now in the laboratory stage appear to justify great new expectations for the transistor in the next five years. Laboratory developments and experiments point to future high-power high-temperature units.

When the transistor was first announced by Bell Telephone Labs in July 1948, its many potential advantages fired the imagination. Some of these were: Long life; one voltage source; no warm-up time required; small size; and from the aviation industry point of view, low power consumption.

From the application standpoint, however, the transistor is surrounded by disappointments. Of the many commercial transistor applications foreseen in 1948, only two have come to pass. One is the use of transistors in telephone exchanges; the other, in hearing aids.

In performance, the only present claim to superiority that transistors can make over electron tubes is their efficiency in amplifying weak signals. In other respects, commercially available

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transistors run a poor second to tubes. Fink cited examples in which the following characteristics of transistors and electronic tubes were compared: noise; operating frequency; bandwidth; power rating; and operating temperature.

Scientists are fast learning more about the principles underlying improvements in transistor performance. For example, high-frequency performance in the junction transistor is now known to depend on rigid control of the small dimensions; the junctions between the three elements of the transistor must be extremely flat and the middle element must be very thin.

Transistor noise reduction depends upon getting high purity germanium initially, and then carefully controlling the amount of impurity added.

Increased transistor power ratings require equal distribution of heat over larger areas of the junction to prevent hot-spots as well as construction techniques that will rapidly conduct heat away from the junctions.

"Really high-power high-temperature operation still awaits the development of a non-germanium transistor, probably one made of silicon," Fink states. Silicon has been considered a likely transistor material for some time, but it is extremely difficult to obtain in the pure monocrystalline form needed for transistors.

Fink expects this problem to be solved soon, however, resulting in a new family of transistors. These would effectively combine much higher power capabilities and no important temperature limitations.

To obtain high-frequency performance in some of the new experimental transistors requires building dozens or hundreds to get one unit with the desired characteristics.

What is needed is a new family of transistors that not only have the desired improvements in performance but can also be manufactured reliably on automatic machinery. Some of the new experimental transistors show promise in this respect.

For these reasons, Fink concludes that the future of the transistor depends not only on the solid-state physicist and chemist, but also on the development engineers who can apply their basic knowledge to a transistor design that can be mass produced by automatic machines.

SPEED CASE STEEL PLATE MAKES AMES A HARDNESS TESTER BETTER INSTRUMENT

A Model 4 Ames Portable Hardness Tester manufactured by Ames Precision Machine Works, Waltham, Mass. is shown above. The dial is direct reading, indicating Rockwell A, B or C scale hardness on thicknesses up to 4".

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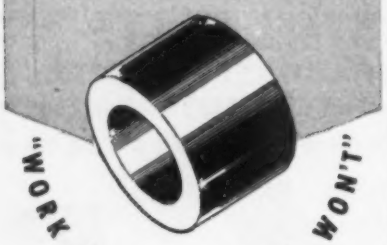

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Safety Suggestions for Pneumatic Circuits

To the Editor:

The article on "Pneumatic Safety Circuits" by H. L. Stewart, which appears in the July 1953 issue of *Product Engineering* is, in general, an excellent and much needed article. The problem of machine control is one of the most difficult and least understood by both safety engineers and machine designers in relation to safety.

There are, however, some weaknesses in the various circuits which should be brought to attention, because of the vital importance of complete safety in control circuits of this type. In our own experience, we have had enough examples of improper operation of machines to make us extremely conservative with respect to controls upon which a man's safety depends. While the author points out the necessity of "fail-safe" operation, it does not appear that in the development of the article adequate attention has been given to this feature.

I have not had sufficient time to study all of these circuits and to figure out what would happen in event of failure of any of the various components. However, it is evident that in some cases there is complete dependence upon a series arrangement of valves. In such an arrangement, there is no protection for the operator if valves should stick in the operating position or be deliberately blocked open. We have found it desirable in such circuits to provide an interlock or cycling type of circuit which requires that all valves be restored to the normally closed position before a new cycle can be initiated, and this, at least, provides a check of the operation of the valves once in each cycle.

It is also very desirable in the prevention of improper operating practices to arrange for simultaneous or nearly simultaneous operation of the

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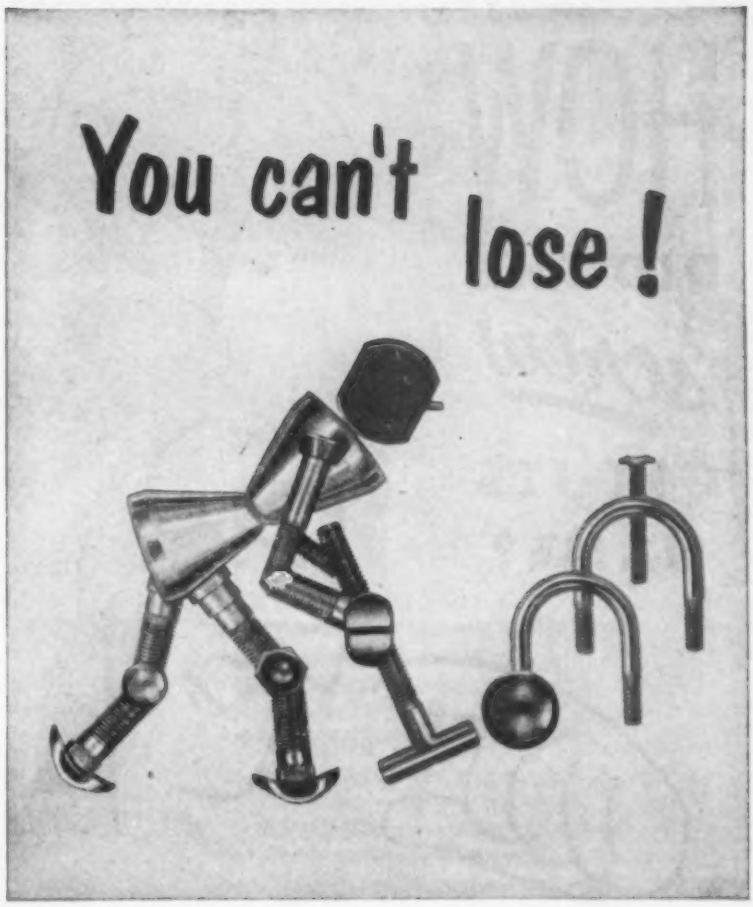
starting buttons or valves. This makes it difficult for a man, for example, to operate buttons by one hand and one knee, or to have two men operate a device intended solely for one-man operation.

While the majority of operators are aware of the reasons for the installation of safety devices, and are sufficiently alert in regard to their own safety, it is true that in many hours of operating experience an occasional operator may try various unsafe operating methods. The safety engineer must be alert to such possibilities and must take precautions in control circuits that may seem extreme at the outset.

In the case of machines that have such a relatively slow operating stroke that there is opportunity for a man's hands to reach the danger zone before completion of the closing cycle, it is, of course, very important that the circuit be arranged to stop the machine rapidly if any control button is released. This is usually done by a braking mechanism, but it is not sufficient to place complete reliance upon mechanical brakes, and a stop bolt should be included in the assembly to stop the machine completely if there is any mechanical failure of the normal clutch and brake or other actuating means.

The operation of a stop bolt should be independent of the normal operating circuit. The bolt should be withdrawn at the beginning of the stroke, and should return to position to stop the machine in its closing cycle. Such a device, of course, does not give protection in the first portion of the stroke, but will serve to stop the motion of the machine at the end of a complete cycle and will prevent recycling. Where a series of valves is used, it is possible to use entirely separate valves actuated by the same push button or handle to provide a completely independent operation of the stop bolt. It is also possible, in circuits having a simultaneous operation interlock, to secure this protection without separate valves.

We have had sufficient experience with electrical control failure to make us extremely conservative in regard to electric interlocking circuits for safety purposes. Magnetic contactors sometimes stick and sometimes rebound and close by themselves due to vibration perhaps aided by residual mag-



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HOW DID THE *screw* GET ITS NAME?

The word "screw" is supposed to come from the Latin "scrofa" which has been defined as "a digger," from the habit of swine, who are fond of rooting up the earth with their noses. However, at least one man disagrees with the explanation. He figures that the etymologists have picked the wrong end of the pig. To him, the curly tail looks more like a screw than the nose does. Heads or tails, tradition has made the word part of the language.

Today, Allmetal—maker of stainless steel screws, bolts, nuts, and many other stainless fasteners—owes its good name to a tradition of high quality and fast service. If you need anything from our line, just give us the word.

Our 96-page catalog contains engineering data and weights as well as sizes and dimensions of stock items. If you want a copy, send us a note on your letterhead. Ask for catalog 53F.

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netism, so that we are hesitant to place full reliance upon contactors.

More recent contactors of very good design have been quite free of these difficulties, but there is always the possibility of failure in the control circuit or the switches themselves, so that it is necessary to have a recycling type of circuit which will check the contacts each time. In other words, every start button must be opened before a new cycle can be initiated and must be an electrical check on these contacts every stroke.

Because of failures due to accidental grounding of the control circuits, it has become our practice to operate control circuits by a small transformer connected to the power supply of the machine to provide a reduced voltage for the control circuit. This transformer is grounded, and there is a small fuse in the live line. With this arrangement, any electrical ground on the circuit will blow the fuse but will not actuate the machine. A similar degree of safety may be secured by the use of double-pole start and stop buttons.

We are most appreciative of anything which can be done to improve safety in machine circuits, as this is a field in which there are many difficulties. Very frankly, we are still a long way from having the answers in much of our own practice. We would appreciate the opportunity of discussing control circuits with Mr. Stewart or with others who may be interested.

—ALLAN L. COBB
Safety Director
Eastman Kodak Co.

To the Editor:

I want to compliment Mr. Cobb on his very fine letter and for the constructive criticism that it contained. All of us should be safety conscious in the design of Pneumatic Circuits where there is any possibility whatsoever of injury to the operator, machine, or work piece if a failure should occur.

While in this article I have tried to show some of the basic safety designs of various Pneumatic Circuits, I recall that additional safety devices could be placed in these circuits if the operation warranted. Nearly all the circuits shown in the article have been in operation for some time, and have proven extremely satisfactory in high production service.

In designing Pneumatic Safety Cir-

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Wirelon looks like a jewel, has the strength of steel and the toughness of nylon. It's a different kind of rope, made by a process in which nylon is extruded around Rochester quality steel cable.

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Can Wirelon do something better for you? Do your **products or processes** require cable which resists fatigue and wear, is good looking, easy to handle, strong and long-lived? Do you have a **new problem** which Wirelon's stamina, safety and jewel-like handsomeness might solve? Write us on your letterhead and we will send you a sample of Wirelon, with specifications, so you can explore its possibilities.

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BIMETAL
CONTROLS
THE
FLY-KING

FLY-KING, a constant, automatic instrument of destruction of flying insects, operates at a pre-determined temperature, protects 15,000 to 20,000 cu. ft. in safety and is guaranteed, because of a strip of Chace Thermostatic Bimetal which controls the unit.

In operation, the Fly-King is attached to a wall, up out of the way; its ceramic warming cup filled with a chemical supplied with the unit. A red pilot light indicates when the Fly-King is plugged in. It may be left connected permanently, the Chace Thermostatic Bimetal forever guarding its efficient and safe operation

Under the warming cup at the top of the unit is a clay heating brick (1) in which is mounted a strip of Chace Thermostatic Bimetal (2) and a contact spring (3). Each is fitted with an electrical contact point. An adjustment screw (4) controls the position of the spring. Current flows through the bimetal strip and spring when the contact points are closed, heating the element brick. As the temperature rises, the bimetal bends away from the spring. At 234 degrees F. the contacts separate and break the circuit. The bimetal then cools, the contacts close and the cycle is repeated to control accurately the evaporation of the chemical at its most effective rate.

So accurate is the control, that a quarter turn of the adjusting screw will change the maximum temperature limit 5 degrees.

This illustrates but one of the many applications of Chace Thermostatic Bimetal as the actuating element for temperature responsive devices. If your product responds to, indicates or controls temperature changes, actuate it with dependable Chace Thermostatic Bimetal. Write today for our 32-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing condensed engineering data.

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cuits, there are usually two things that must be taken into consideration: first, to make the circuit as fail-safe as possible; and second, to design it at a price.

From a Safety Engineer's standpoint, perhaps the second item does not seem at all important. However, in selling equipment, the price is almost always a factor, and it is not too hard to design such equipment that will place you out of the buyers market.

As for electrical devices in various Pneumatic Circuits, it would be almost impossible to design some of the more complicated circuits without using magnetic contactors, etc., in order to complete the various intricate operations. We find that there has been vast improvement in electrical controls in the past few years in order to meet these complicated requirements. By designing the circuit so that if any electrical failure should occur, the circuit will be automatically shut off, very little trouble is usually encountered.

I would certainly like to be able to sit down and discuss these various safety devices with him. It is my belief that the more personal contacts that the designer can make with the user of safety devices, the better he can design these devices to meet all safety requirements.

—H. L. STEWART
Logansport Machine Co., Inc.

Problem: Where to Find Insulated Screws?

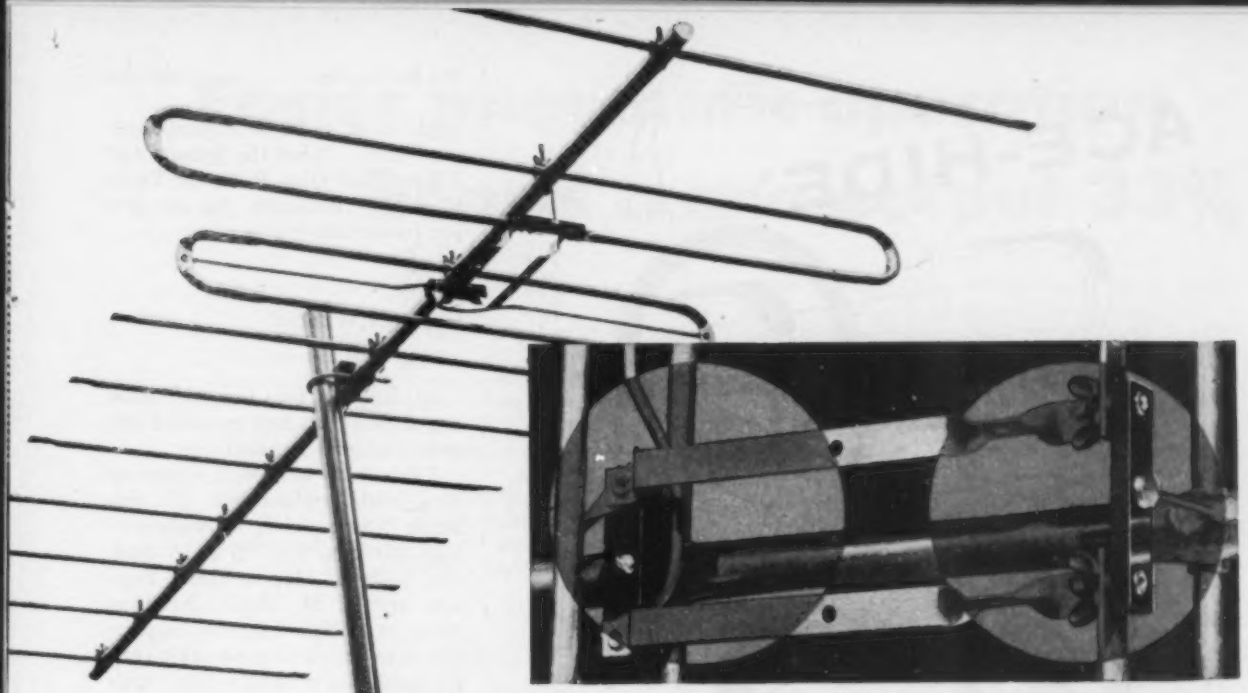
To the Editor:

We are interested in obtaining sources for an insulated head $\frac{9}{32}$ machine screw. The screw will have 135 volts on it and the insulating material should withstand a torque of 2 in.-lb. without cracking or chipping.

Any information which you can supply to us will be appreciated.

—E. A. FREED
General Instrument Corp.

Ed—This is a problem shared by many people in the electronics and electrical fields. At least two companies make what they call an insulated screw: The Hartford Machine Screw Co., Deerfield Road, Hartford, Conn.; and Reed and Prince Mfg. Co., 100 Duncan St., Worcester, Mass. Or you



economical PHENOLITE low-loss block insulators...on famous *CHANNEL MASTER* TV antenna

Channel Master's famous Futuramic antenna combines Broad Band TV coverage with the high gain and directivity of the Yagi. Utilizing Phenolite low-loss block insulators—the Futuramic is the one antenna that solves *today's* reception problem, yet will also receive *tomorrow's* VHF channels.

This use of Phenolite is typical of its countless applications in the electrical field. Phenolite, about one-half the weight of aluminum, is the perfect insulating material for high and low voltage applications.

It possesses an unusual combination of properties. Phenolite has great mechanical strength and high resistance to moisture; ready machinability; is unaffected by solvents and oils. It can be easily punched, sawed and sheared. Tough and with high impact strength, Phenolite is one of the strongest materials per unit weight known.

Available in various grades and colors; in sheets, rods, tubes, and special shapes. Write for literature and engineering information—

Channel Master's two dipole system—connected by Phenolite low-loss block insulated harness—makes possible the high gain and directivity of the Futuramic broad band Yagi antennas.

Illustrated: Futuramic Model 1173 broad band Yagi antenna covering channels 7-13, Channel Master Corporation, Ellenville, New York.

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might try an all-fabric or plastic laminate screw. Either the Sythane Co., 6 River Road, Oaks, Pa., or the Taylor Fibre Co., Norristown, Pa., can give you further information.

Reprints Wanted

To the Editor:

In your June, 1953 issue of *Product Engineering*, you have published two articles of great interest to me.

I should like to know if reprints of these articles are available. The first article "Developments in Analysis of Lugs and Shear Pins" by M. A. Snelcon, Structural Methods Group Engineer and F. M. Hoblit, Structures Engineer, Lockheed Aircraft Corporation is an extremely good article from the standpoint of design. The second article, of which I should like to have all seven parts, is "Insuring Your Progress Through Research".

If these informative articles are available and there is any charge for issuing copies of same I would appreciate notification. —H. A. MONSOR
Oliver United Filters Inc.

Ed—Reprints are on their way.

To the Editor:

The article, "Design of V-Belt Drives", in the September issue is one of the finest we have ever seen on the subject.

We would be interested in obtaining twenty copies of this article, including the gatefold insert, for distribution in our drafting room. If reprints are or will be available, we would appreciate a price quotation for twenty copies so that we may order.
—THOBURN F. PETERSON
Minnesota Mining & Manufacturing Co.

Ed—We've sent you 20 copies of the insert, but unfortunately, no reprints of the article itself are available. If extra copies of the insert are needed, they are available at 10 cents per copy.

To the Editor:

We should like to make a number of copies of the article "Developments in the Analysis of Lugs and Shear Pins", *Product Engineering*, June, 1953, pages 160 to 170. These

Easier pneumatic operation boosts crane output 33%

Air is now used to operate the throttle and clutches of this 50-ton locomotive crane. As a result, scrap metal, iron ore, and freight are handled faster at the Port Covington yard of Western Maryland Railway Co.

Formerly, the operator of this crane had an awkward ceiling-mounted steam throttle valve, 4 clutch levers, and 4 direction levers to manipulate. This jumble of manual controls slowed up operation and reduced the operator's efficiency.

In 1950, this system was vastly improved with Westinghouse Air Brake pneumatic control. Just *one* Controlair® valve replaced the old throttle valve and 4 clutch levers. This new valve is mounted right in front of the operator, always in easy reach. He accurately controls speed and clutching with *one movement of one hand*. This easier control doesn't tire him out . . . keeps him alert and at peak efficiency all day . . . enables him to move ⅓ more material a day.

Westinghouse Air Brake Co. supplied the complete pneumatic system for this crane, from control valves to air compressor. It has worked 8 hours a day, 6 days a week since February, 1950, and has given no trouble.

Westinghouse pneumatic controls can do a comparable job on your equipment. For complete information, write to Westinghouse Air Brake Co., Industrial Products Division, Wilmerding, Pa.

Daily tonnage was increased 1/3 on this 50-ton locomotive crane with a new Westinghouse Air Brake pneumatic system. Westinghouse controls simplify operation and reduce operator fatigue.

This Westinghouse Controlair® valve takes the place of one steam throttle valve and 4 clutch levers. It saves time and increases productivity of the crane.

Westinghouse Air Brake
COMPANY

INDUSTRIAL PRODUCTS DIVISION WILMERDING, PENNSYLVANIA

Factory Branch: Emeryville, Calif. In Canada: Canadian Westinghouse Co., Ltd., Hamilton, Ontario

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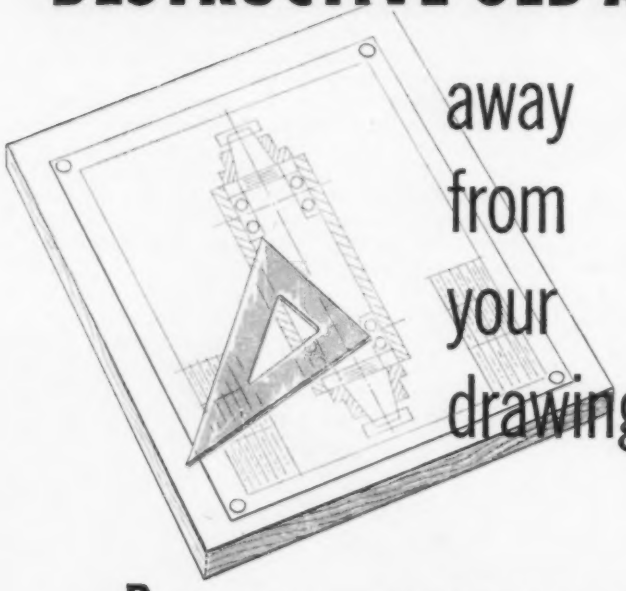

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We should appreciate your permission to make these copies.

—GLENN ORLOB
Boeing Airplane Co.

Ed—Granted.

Check List For Springs Not For Release

To the Editor:

The September, 1953 issue of *Product Engineering* contained an article concerning a check list for springs used by the Ford Motor Company. We assume that this check list is either a part of their engineering department's standard procedure, or is a separate check list used at the time the spring is designed. If the latter is true, and the check list is an individual piece of material, we would very much appreciate having one copy. This sort of check list, frankly speaking, would be of great benefit to our customers. —F. H. BOOTH
Milwaukee Spring Co.

Ed—You were right the first time. The check list is part of Ford's standard procedure, and is not available for release. For information on it, you might contact J. R. Gustafson, Ford Motor Company, Dearborn, Michigan.

New Course In Product Development

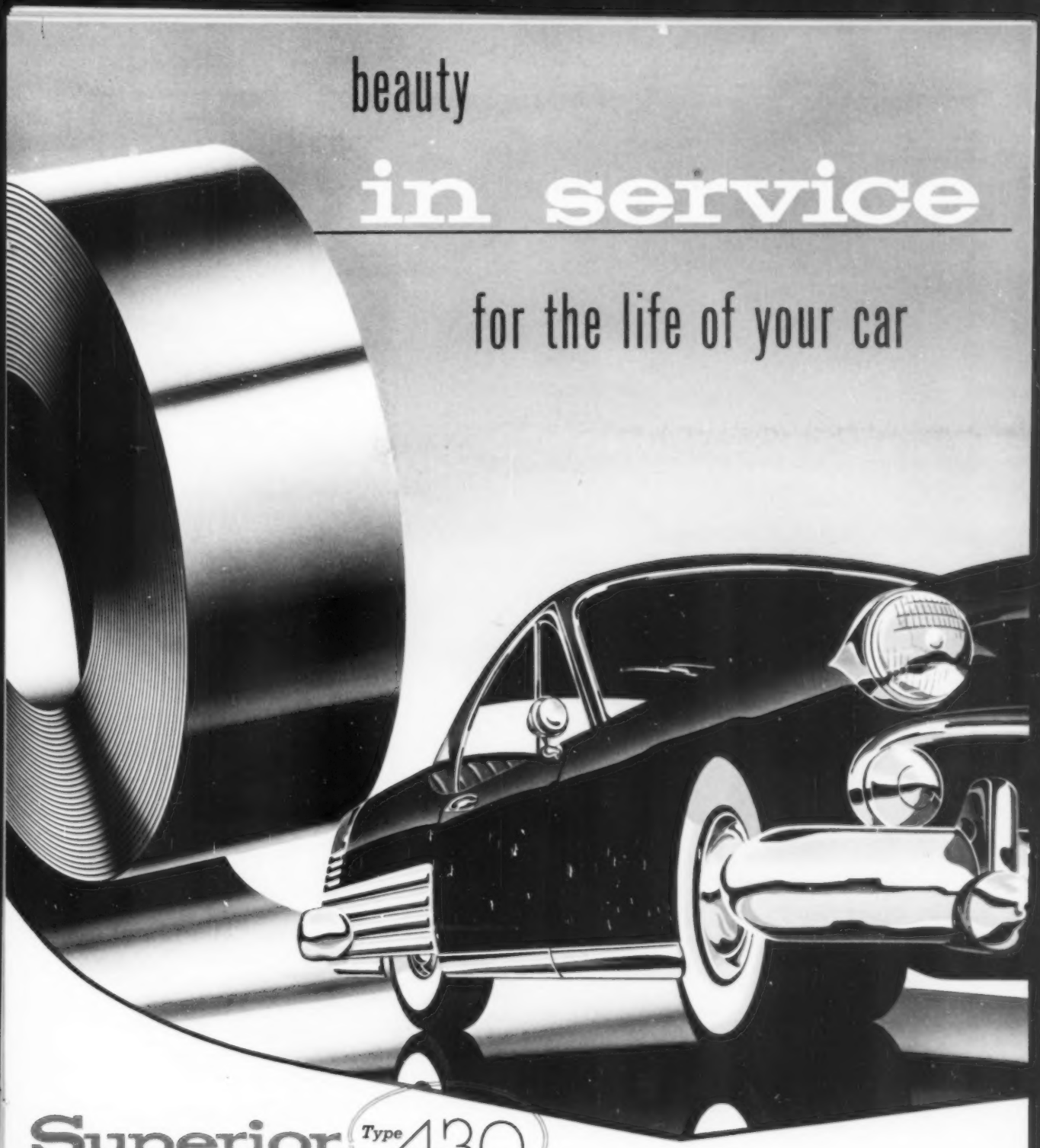
To the Editor:

We are establishing a course in "Product Development" at the University of Michigan this semester, which will treat a number of aspects of the design and development process. Among these is the general area of engineering organization and operations.

In May of 1952, you published a special section, "Engineering Your Company's Future", which impressed me very much at the time. Now it appears that this series of articles could prove of real value to our students in the aforementioned course.

—R. EVALDSON
College of Engineering
University of Michigan

Ed—Sorry, but we're completely out of reprints of the section. However, we've sent you a list of available reprints that might be of value to you.



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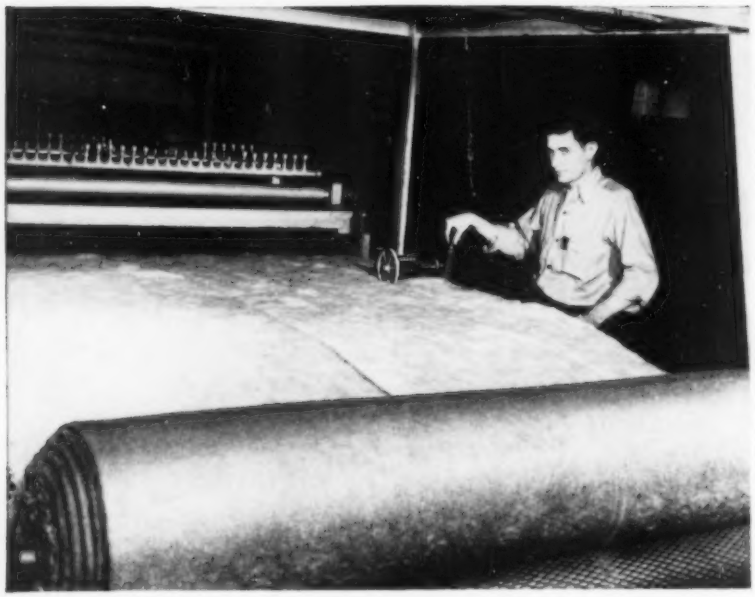

Millions of tiny glass fibers, smaller than human hair, are collected into lightweight Super·Fine blankets in rolls up to 72″ wide, 200′ long, at the Fiber·Glass Division of Libbey·Owens·Ford Glass Company.

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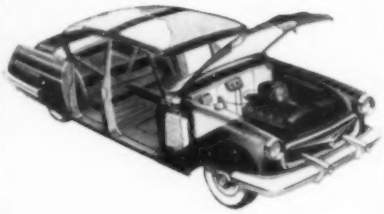
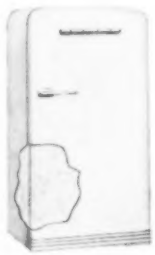
NEWS ABOUT L·O·F SUPER·FINE



L·O·F Super·Fine insulation benefits many products. In automobiles, Super·Fine is used under hood, muffles airborne noise in the high-frequency range. Super·Fine is also used in the dash, roof, front quarter, fire wall, trunk and package tray. Standard Super·Fine may be used for temperature ranges from sub-zero to 450 F., or higher with a special binder.



Space-saving properties of Super·Fine open up new design possibilities for the refrigeration field. Thinner-wall construction with Super·Fine means inside cubic capacity of units can be increased, or over-all dimensions decreased.

FREE! Send for free booklet "Possibilities Unlimited." Tells how Super·Fine can profit you. Write Fiber·Glass Division, Libbey·Owens·Ford Glass Company, 4113 Wayne Bldg., Toledo 3, Ohio.

NEW BOOKS

Timing Engineering

Myrten G. Saake, Application Engr., 6 x 9 in., 243 pp. Published by Ribble Engineering Co., 74-80 Montgomery St., Jersey City 2, N. J., $5.

This is the first complete, full-length reference book on industrial timers and their application. It covers the basic design, construction and application of timers, with emphasis on automatic machinery and processes.

Chapter I, "Industrial Timing Devices," defines industrial timers and classes them as repeating cycle and reset. It then goes into the questions of why to use timers and how to select a timer.

Chapter II is devoted to synchronous motor driven repeating cycle timers. Considerable space is given to typical applications.

The next chapter covers the characteristics and applications of synchronous motor driven automatic reset timers. Applications include two speed motor timing, pump surge protection, conveyor belts and molding press timing. Chapters IV and V are devoted to two types of automatic reset timers and their applications. Chapter VI discusses multiple circuit automatic reset timers, again with considerable space allotted to applications.

Chapter VII gives the types and uses of direct current timers; Chapter VIII covers automatic reset counters. The final chapter briefly describes timers other than synchronous motor driven. Included are electronic, pneumatic and thermal types.

Fundamentals of Electronic Motion

WILLIS W. HARMAN, *Associate Professor of Electrical Engineering, Stanford University, 6 x 9 in., 219 pp. Published by McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y., $6.50.*

While this book utilizes electron-tube analysis as a teaching medium, it is primarily intended to stimulate and further an ability to cope with new problems and situations. Since particle dynamics, electromagnetic fields, and

The Filter That Manufacturers Install As Standard Equipment

Sump Type (cutaway)

MARVEL SYNCLINAL FILTERS

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Marvel Synclinal Filters are installed on all types of hydraulic and oil recirculating equipment. Illustrated are machines representative of the many which are protected by Marvel Synclinal Filters. Reasons for this overwhelming preference include:
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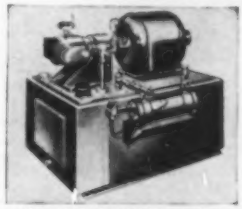
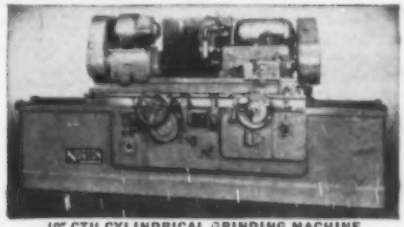
DRILLING RIG. Emsco Derrick & Equipment Co., Los Angeles, California



HYDRAULIC PUMPING UNIT
Denison Engineering Co., Columbus, Ohio



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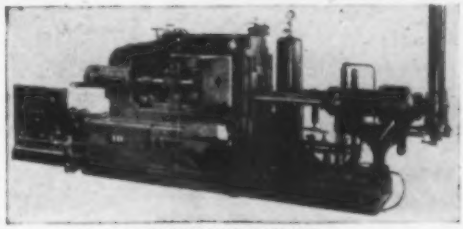

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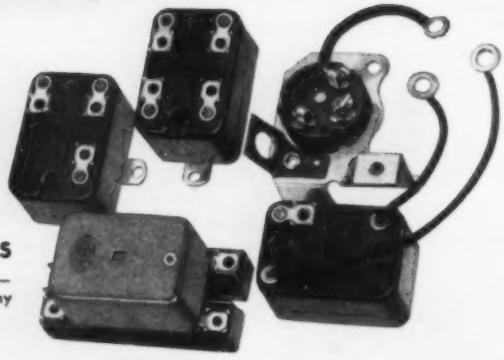

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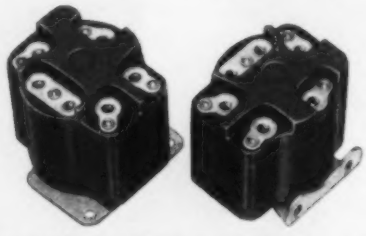

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wave phenomena are all represented in the subject of electronic motion, and the mathematical tools of ordinary and differential equations (and approximate methods when solutions become difficult) find repeated application, the field of electronic devices is well suited for the demonstration of philosophies and techniques of applied mathematical physics.

With the basic stress on the philosophy of analysis, the understanding of what is being done and how it is accomplished are treated in more detail than the mere facility with mathematical manipulations.

After an introductory chapter on electric and magnetic field distributions, the coverage continues with the problem of finding the trajectory of a single electron in a constant electric field. It proceeds through electron motion in magnetic fields, electron optics, static space-change problems, motion in time-varying fields, the concept of space-change waves and their application in various types of devices, the traveling-wave and traveling-wave-magnetron principles, and relativistic electrodynamics.

Recent advances, such as microwave tubes and particle acceleration, are covered as applications of basic concepts. No previous knowledge of electro-magnetic field theory, nor knowledge of any mathematics beyond calculus, is required.

Engineering Electronics

GEORGE E. HAPPELL *and* WILFRED M. HESSELBERTH, *Associate Professors of Electrical Engineering, Purdue University,* 6 x 9 *in.,* 508 *pp. Published by McGraw-Hill Book Co., Inc.,* 330 *West* 42 *St., New York* 36, *N. Y.,* $7.50.

This textbook is suitable for use in a beginning course in electronics for electrical engineering students, especially those planning to specialize in the communications, servomechanisms, electronics or power field. It gives a theoretical and practical treatment of electronics that can serve as a basis for further detailed study.

Material included covers an elementary approach to the physics of vacuum tubes, and the characteristics of diodes, triodes, and other types of multigrid vacuum tubes. Following this is a

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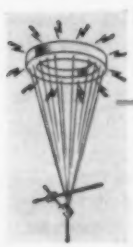

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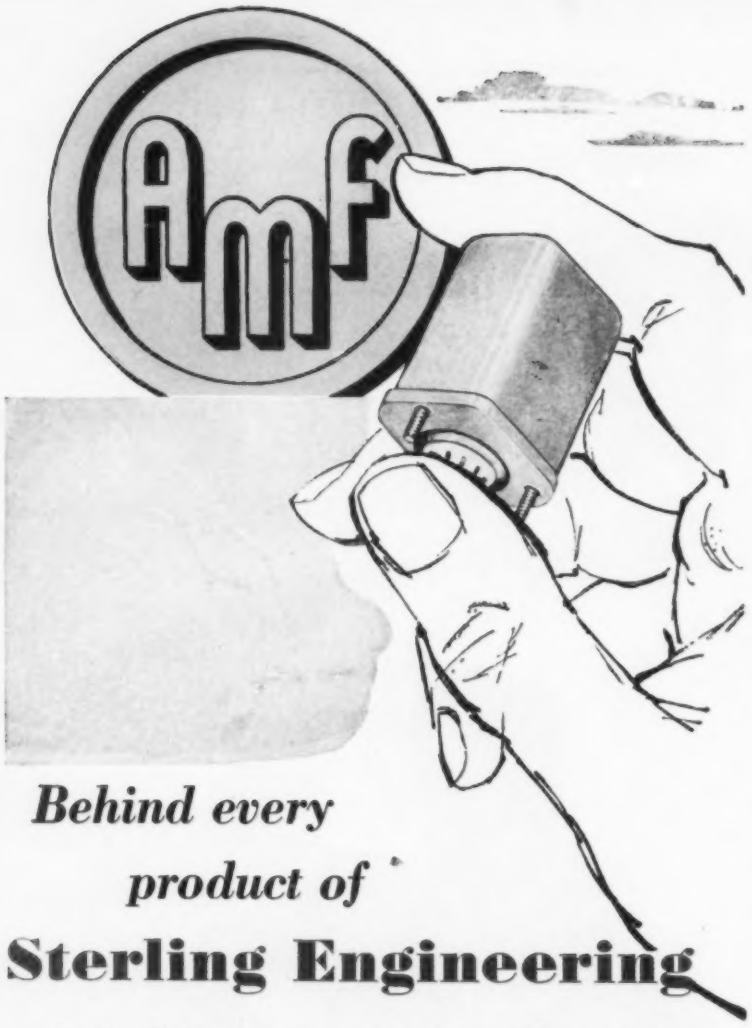

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chapter on concepts important in vacuum-tube-circuit analysis, followed by detailed studies in voltage amplifiers, a-f and tuned-load power amplifiers, feedback amplifier, oscillators and modulation and detection theory and devices. The remainder of the book covers conduction through gases, high vacuum and gaseous rectifiers, photoelectric cells, solid-state electronics and reactance amplifiers.

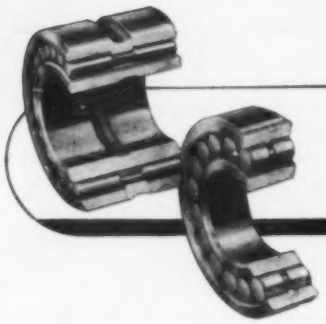
The text stresses: linear equivalent; circuit theorem; graphical analyses; determination of proper operating conditions; use of tube manuals; derivations where practical; and practical examples. Additional information includes: a chapter to give the uninitiated a preview of the subject; graphic treatment of cathode followers; solid-state electronics; reactance amplifiers; cathode bypassing; and material on elementary feedback amplifiers. Most of the chapters include a set of problems and questions intended to give the student a working knowledge of the material covered.

Industrial Specifications

E. H. MacNiece, Chief of Education & Training for Mutual Security Agency in Europe, 6 x 9 in., 158 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., $4.50.

The author sets forth proven methods of planning, writing, and issuing specifications for the various phases of industrial operation, providing the basic information necessary for the advanced application of these methods. It is the only work to deal with this important area of modern industrial engineering.

The book is an outgrowth of working with specification problems arising when companies wish to improve their effectiveness by the application of statistical quality control techniques. This searching analysis of the part specifications play in industry is fundamentally a discussion of specifications as important requirements for statistical quality control and product development. It carefully relates accuracy of measurement with the ability to better specify, and stresses the relation of technical and economic factors in manufacturing, buying and selling. It also gives essential requirements



Over 33% Greater Capacity For The Same Size

There is a challenge facing manufacturers today to build smaller and more compact machines with extra precision and to combine more operations in each machine. This makes the selection of the proper bearings extremely important. A definite plus factor in this selection is the availability of a precision bearing that will deliver extra load carrying capacity in a minimum amount of space.

Obviously roller bearings, and particularly those of the small (needle) roller type occupy far less bearing space for equivalent capacity than ball bearings. Roller bearing capacity is built up in proportion to the effective race and roller contact provided. Thus a full type roller bearing *without space wasting cages* should provide the greatest capacity of any type of anti-friction bearing. However, to offer a perfect bearing the resulting full roller complement must be prevented from skewing and binding where misalignment occurs in the application.

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Published Load Rating	8370 lbs.	6700 lbs.	7000 lbs.	5520 lbs.	6080 lbs.

Capacities at 2500 hours average life at 100 RPM

long life, versatility of mounting, and ease of lubrication. Published ratings show the Guiderol CT Series bearing has over 33% greater load carrying capacity than the average of the four highest rated interchangeable bearings. As a result, a Guiderol bearing at least one size smaller can often be substituted with the necessary shaft and housing requirements reduced in size and cost.

How Rollers Are Guided

In the Guiderol bearing design the grooved rollers with full race width contact are prevented from skewing by a center guide rail. Normally the rollers run on a true axis

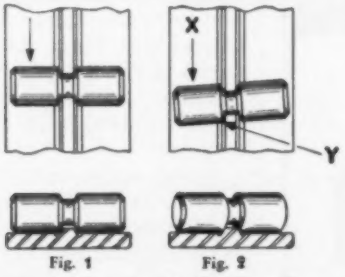
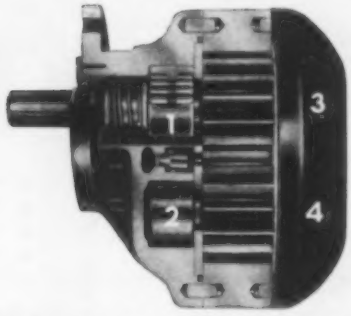


Fig. 1 Fig. 2

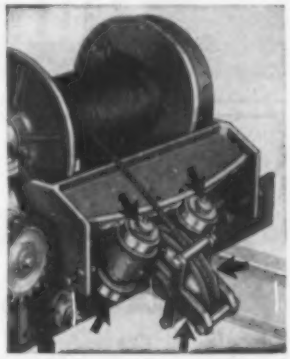
— not contacting the rail and thus need no correcting. (Fig. 1) Should misalignment cause a shift off center (Fig. 2) the leading end of the roller is retarded by contact with the rail at location Y. The trailing end catches up, relieving the rail contact, and the roller then resumes normal operation.

Typical GUIDEROL® Bearing Mountings

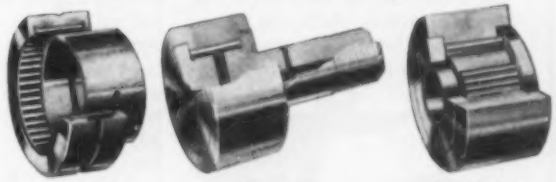


On a Hydreco Gear Pump Idler and Drive Shaft, 4 Guiderol bearings are used. The longer rollers of the Guiderol bearings are effective virtually to the edge of the races. This gives substantial support close to the gear and materially reduces shaft dellection.

Four Guiderol bearings support and guide an automatic spooling attachment across the face of the reel track on a 20,000 pound Gar Wood Reel-Rite Winch. The guided roller principle prevents skewing of rollers in the 4 vertically mounted bearings even with a 10,000 pound angular load per bearing. A fifth Guiderol bearing in the sheave provides added stability and eliminates binding due to off-center loading.



MULTIROL® Bearings



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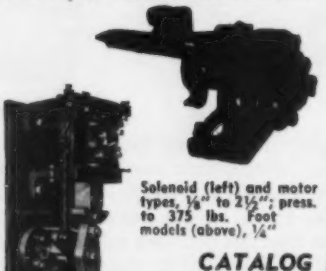
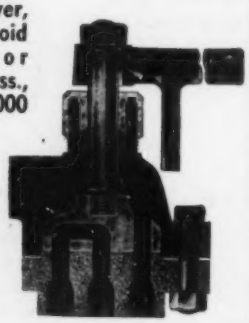


Solenoid (left) and motor types, ⅛" to 2½"; press. to 375 lbs. Foot models (above), ¼"



to 1½"; press. to 300 lbs. Lever models (right), ¼" to 2½"; press. to 5000 lbs.

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for—as well as excellent examples of —raw material, process and product specification.

"Industrial Specifications" offer total coverage of the subject. In Chapter 1, the author compares the accuracy of measurement to the ability to specify. In Chapters 2 and 3, he stresses the careful relationship between economic and technical factors in production. Chapters 4 through 8 give essential requirements for raw material, process and product specification. In the concluding pages the role of specifications in the federal, state and city scheme is discussed; standard procedures and job specifications are documented.

The book shows how good specifications improve relations between those who buy and sell, and recites the advantages of good specifications as a vital factor in our economic well-being. A plus-interest feature of the book is the inclusion of a number of actual specifications issued by some of the leading business concerns and government agencies.

Engineering Metallurgy

BRADLEY STOUGHTON, *formerly Dean of Engineering and Professor of Metallurgy, Lehigh University,* ALLISON BUTTS, *Head of Dept. of Metallurgical Engineering, Lehigh University, and* ARDREY M. BOUNDS, *Chief Metallurgist, Superior Tube Co.,* 6 x 9 *in.,* 479 *pp. Published by McGraw-Hill Book Co., Inc.,* 330 *West* 42 *St., New York* 36, *N. Y.,* $7.50.

This revised fourth edition is an up-to-date study of metallurgy designed to be used by sophomore-junior engineering students, particularly those who do not plan to specialize in metallurgical engineering. Emphasis is on aspects of metallurgy necessary in the continuance of their course and what they must know in the early part of their career.

Subject matter covered deals primarily with metal utilization rather than production. It covers structure, properties, treatment, and working of metals and alloys. Principles and information basic to proper selection of metallic materials in engineering design and construction are given. Enough about production and refining of metals is included to show how

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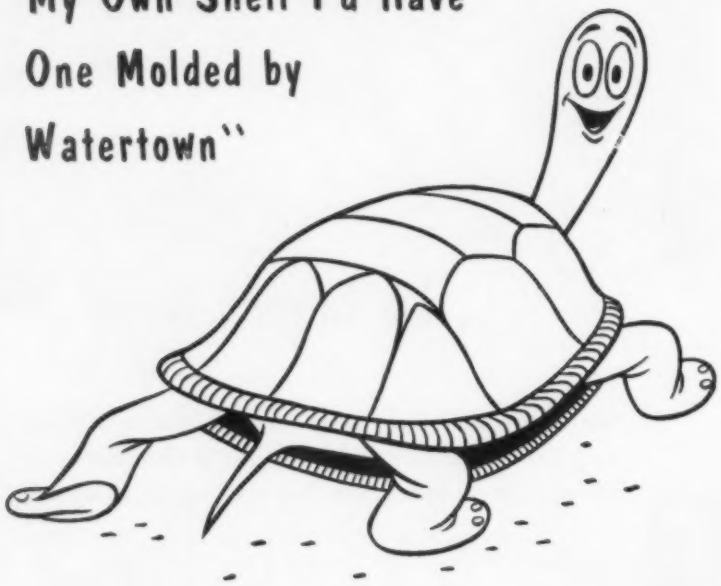

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properties may be affected by the production process, and to afford a well-rounded elementary knowledge.

Subjects which have assumed greater importance have been expanded. Chapters on alloys, heat treatment, metals as materials of construction, and sizing and shaping have largely been rewritten to bring them up to date. Some chapters have been consolidated and others rearranged to save space and make the subject more teachable.

New developments in metallurgy since the third edition and especially since World War II have been added. They include: metallurgy in atomic energy development, machining and machinability, plastics, new welding methods, new casting methods, new methods of testing such as acoustic and supersonic, new types of steel and cast iron, new non-ferrous alloys, and time-temperature-transformation curves.

Partial Differential Equations

KENNETH S. MILLER, *Asst. Prof. of Mathematics, New York University, 6 x 9 in., 254 pp. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y., $6.35.*

The attempt in this book is to present the subject of partial differential equations at a level that can be appreciated and used by the engineering student. Only an elementary knowledge of ordinary differential equations is a prerequisite to its understanding. The guiding light throughout the book is the practical solution of partial differential equations; little attention is paid to questions of existence, uniqueness, and convergence. It is felt that students (upper classmen or beginning graduate students) are not interested in such considerations, and that these topics might obscure the fundamental techniques rather than add to the clarity of the exposition. Furthermore, since all illustrative problems are based on physical systems, physical reasoning can be used to guarantee the existence of a solution intuitionally, and make plausible the fact that the function we formally obtain is actually a true solution.

In Chapter I, some of the more common partial differential equations associated with such phenomena as vibration, heat flow, electricity, and

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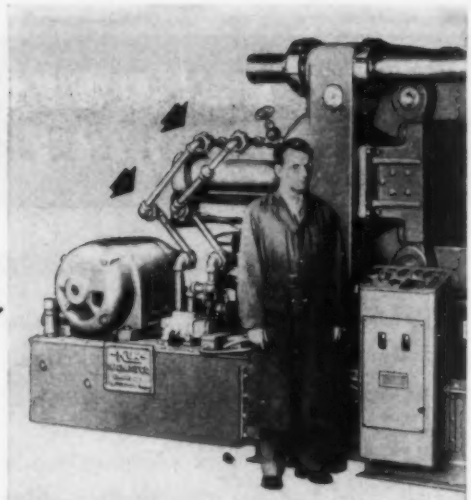

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SAFETY is one significant reason for using Barco Swivel Joints on HYDRAULIC APPLICATIONS. Pressures often run to 3,000 psi, or more. For such service, metal piping and flexible joints offer important advantages. *Non-rigid* type connections can burst instantly without warning, causing injuries to personnel, fire, and waste of valuable oil. *Insurance companies counsel against such hazards.*

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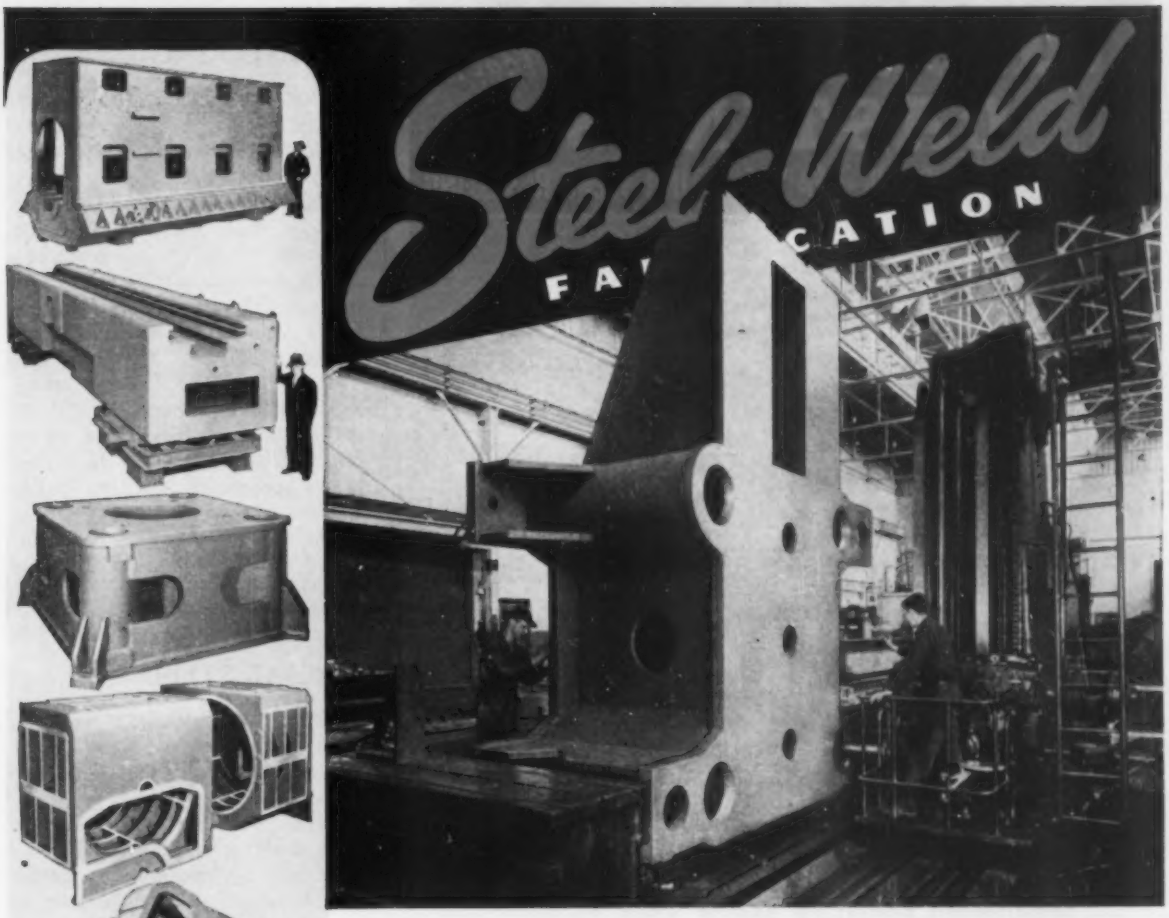
elasticity are derived. The second chapter is devoted to an exposition of fundamental facts concerning Fourier series. These ideas are, of course, useful in themselves; but their main value, from the author's point of view, is their use in solving partial differential equations. In Chapter III, the techniques of Fourier analysis developed in Chapter II are applied to the equations derived in Chapter I, and a number of equations are solved by the method of separation of variables. Certain problems (for example, those involving nonperiodic functions) are not amenable to the method of Fourier series, and so in Chapter IV the Fourier method is extended to arrive at the Fourier integral, which makes it possible to solve a wider class of problems. The Fourier integral also leads to the "transform method" of solving partial differential equations. In Chapter V, the method of separation of variables is discussed in conjunction with changes in the coordinate systems; this leads to certain ordinary differential equations of practical and theoretical importance, namely, Legendre's, Bessel's, and Mathieu's equations. A digression must be made to consider various elementary properties of the Legendre, Bessel, and Mathieu functions. Chapter VI gives the student some insight into the general structure of differential operators.

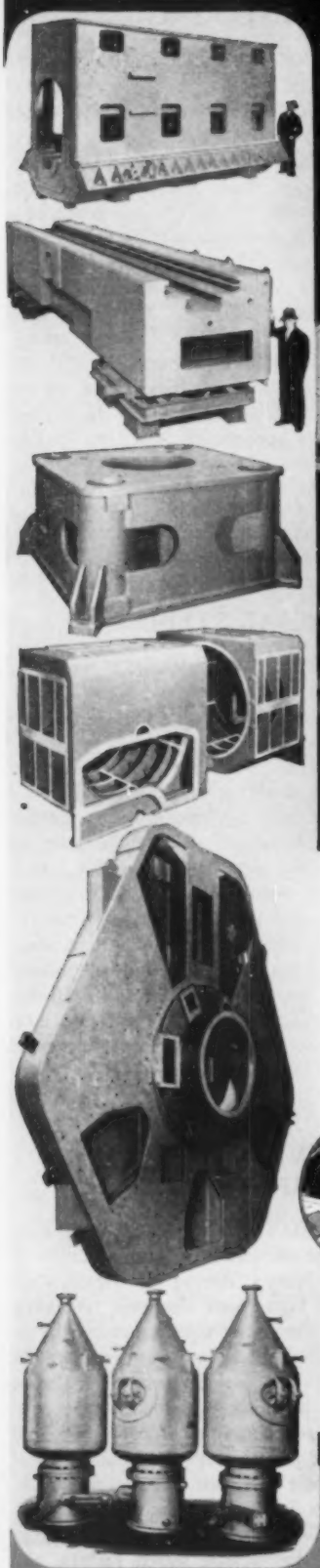
Other methods of solution of partial differential equations, such as the Laplace transforms and numerical procedures, have not been included in this book, both in order to limit its size and scope, and because excellent texts on these particular methods of solution are already available.

American Standard Involute Spline and Serration Gages And Gaging (ASA B5.31-1953)

8½ x 11 *in.*, 22 *pp. Published by the American Society of Mechanical Engineers,* 29 *West* 39 *St., New York* 18, *N. Y.*, $1.25.

This standard covers the subject of gages used for different types of fits and several systems of gaging to meet the demands of various industries. It is based on 1950 standards on Involute Splines and Involute Serrations. The basic principles are applicable to all involute splines and serrations.





Use WELDED STEEL
for Greater Strength
with Less Weight!

The forty ton Press Platen above, and the parts and assemblies illustrated at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for hundreds of manufacturers of heavy machines and other mechanical equipment. If parts of your product could be redesigned and produced to better advantage through Steel-Weld Fabrication, or, if you require a limited number of large heavy pieces in which pattern costs are a consideration, you can turn to The R. C. Mahon Company with complete confidence . . . personnel and facilities are available within the Mahon plant to do the complete job from drawing board to finished machining. You will find in the Mahon organization a unique source with complete ultramodern fabricating, machining and handling facilities to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Mahon's Insert in Sweet's Product Design File, or write for further information.

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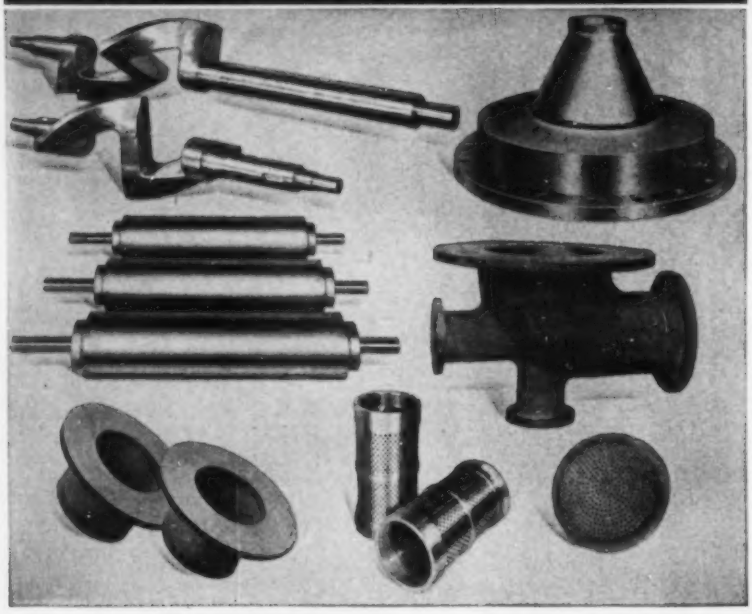
MISCO *Stainless Steel* CASTINGS

CORROSION RESISTING · HEAT RESISTING · WEAR RESISTING



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DIVISION OF EBALOY, INCORPORATED

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MISCO
Heat and Corrosion Resistant Alloys

FILM SELLS ENGINEERING

FACULTY MEMBERS at Michigan State College's School of Engineering have a new wrinkle to help sell high school students on an engineering career. Under the direction of Paul Dekoning, Assistant Professor of Mechanical Engineering, the college has produced a 20 min, full-color movie that describes training, job opportunities and the future in the field of mechanical engineering.

Called "Mechanical Engineering," the film uses both campus and industrial facilities for background. Michigan State alumni explain the various phases—production, design, testing and research—of the profession.

The college has made the picture available for showing to interested groups without charge.

SPECIAL STEEL

LUKENS STEEL COMPANY is now making a special steel for sulphate digesters, widely used in the paper pulp industry.

Of the rimming type, similar to those steels used in digester service some years ago, the new material has the advantages of a combination of the desirable qualities of old-type rimming steels with the characteristics necessary for easy fabrication of the heavy gage metals used in this service.

Lukens supplies this special material in a range of plate widths, thicknesses and lengths, as well as offering it in a broad range of spun and pressed head sizes and shapes.

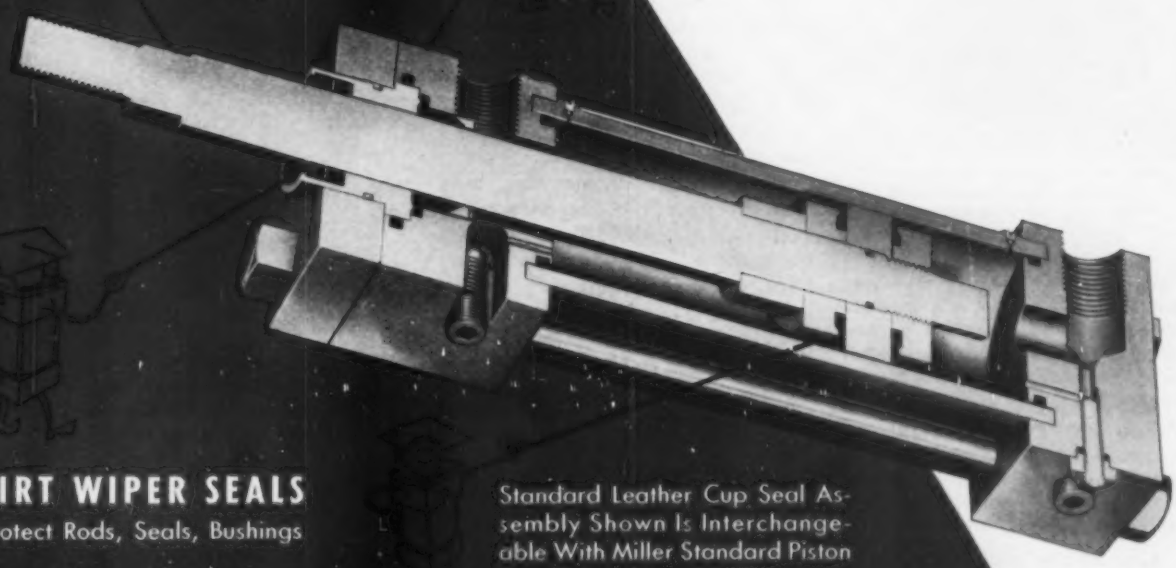
NEW BUAIR COMPUTER

WASHINGTON—An eight ton electronic computer is being installed at the Navy's Bureau of Aeronautics. This high speed electronic tabulating and computing equipment consists of a digital general purpose computer and accessories including three magnetic tape handling equipments, type editing and printing equipments, one high speed printer, with IBM punches, and a motor generator. The computer operates in the coded decimal system, utilizes magnetic tape for input of data, has a tape search feature, and contains a magnetic memory drum that

Miller HIGH PRESSURE HYDRAULIC CYLINDERS

HARD CHROME PLATED PISTON RODS
Prevent Scratch-Damage, Nicks and Rust

SOLID STEEL HEADS, CAPS and MOUNTINGS
Eliminate Breakage



DIRT WIPER SEALS
Protect Rods, Seals, Bushings

Standard Leather Cup Seal Assembly Shown Is Interchangeable With Miller Standard Piston Ring Piston Assembly

WRITE FOR CYLINDER BULLETINS H-104 and A-105

Complete Miller cylinder line includes: air cylinders, 1½" to 20" bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

MET J. I. C. HYDRAULIC STANDARDS years before their adoption in 1949.

SPACE-SAVING SQUARE DESIGN originated by Miller in 1945.

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

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MILLER MOTOR COMPANY

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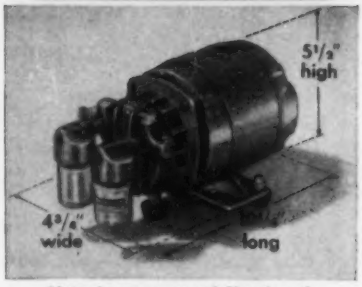
AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS • COUNTERBALANCE CYLINDERS

Announcing
Two Compact
NEW
GAST ROTARY Integral-MOTOR
AIR PUMPS
FOR ORIGINAL EQUIPMENT
APPLICATIONS AND PORTABLE USES



Note the compactness! Yet these Integral Motor-Pumps (basic Model No. 0406 shown) deliver .6 CFM—to 15 PSI or 25 In. Vac. 1750 RPM with 1/12 HP G.E. Motor.

It's a VACUUM PUMP! For vacuum, Model 0406-V2-154X has already proved its advantages as a component of industrial instruments requiring air flow; as a portable air sampler, etc.

It's an AIR COMPRESSOR! For pressure, Model 0406-P2-154X is in use on special machines for textile wear testing; as a laboratory compressor, etc.

Both OIL-LESS AND STANDARD LUBRICATED TYPES OFFERED - VARIOUS ACCESSORIES

You can get absolutely oil-free air with completely oil-less models (never need lubrication); also standard lubricated models. Altogether, Gast offers a wide range of Integral Motor-Pump Models from 1/12 to 1/3 HP. *Investigate now!*

Write FOR NEW DATA SHEETS on 0406 Integral Motor-Pump Models.

Same model, but with handle, gauges, nipples, etc., to show typical accessories we can furnish.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY
AIR MOTORS - COMPRESSORS - VACUUM PUMPS
(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

will store 11,000 nine digit words or numbers.

The computer performs a multiplication or division in 15 milliseconds and addition and subtraction at even faster speeds.

The tape editing and printing equipments will permit decentralized preparation, searching, correction and printing of tapes in the operating divisions. The tapes will be transmitted to the computer for actual tabulations and computations. The high-speed printer will provide output from the computer at a rate of 600 lines of 120 characters each per minute.

The computer will fill the need for a more reliable method of tabulating and computing jet plane problems, which are of great mathematical complexity. It will also permit more efficient planning for ordering, distributing and scheduling maintenance of aircraft, components and supporting parts. With the computer, Bureau needs can be computed in one day and the results sent to the proper destination the next day.

The 45,000 lb memory unit, the most delicate part of the computer's mechanism and one of the largest in the world, was flown from the West Coast. Other components such as the control units, high speed printer and special generator, were shipped in a specially padded and sealed truck from the manufacturer, the Computer Research Corporation, Hawthorne, Calif.

GOVERNMENT RESEARCH

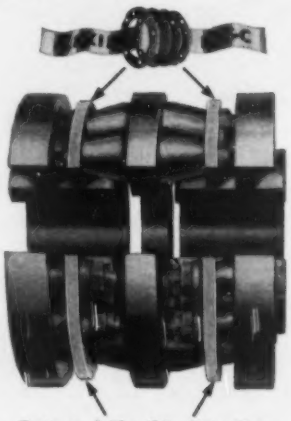
BOTH OBLIGATIONS AND EXPENDITURES of Federal agencies for scientific research and development are expected to drop in fiscal year 1954 from the record totals established in previous years, according to the latest estimates compiled by the National Science Foundation.

Estimates of obligations for research and development are $2,074 million for 1954 compared to $2,187 million for 1953; expenditures are estimated at $2,187 million in 1954 and $2,205 million in 1953. Since the lag between obligations and expenditures has averaged about 9 months over the past several years, the decline in obligations for 1954 will presumably be reflected in a further decrease in expenditures in fiscal 1955.

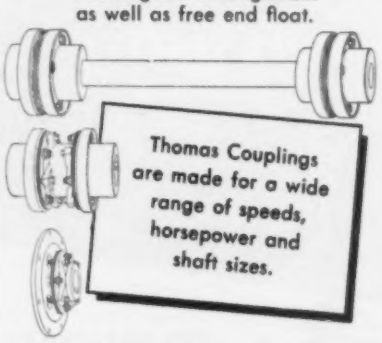
These estimates, revised as of Aug-

Specify THOMAS ALL METAL
FLEXIBLE COUPLINGS
for Power Transmission to avoid Costly Shut-Downs

DISTINCTIVE ADVANTAGES	
FACTS	EXPLANATION
NO MAINTENANCE	Requires No Attention. Visual Inspection While Operating.
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.



Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.



Thomas Couplings are made for a wide range of speeds, horsepower and shaft sizes.

THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT

NO MAINTENANCE PROBLEMS

ALL PARTS ARE SOLIDLY BOLTED TOGETHER

Write for our new Engineering Catalog No. 51

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

yesterday's experience is today's knowledge

METAL POWDER PARTS BY MORAINE

While we've had a large amount of experience (over a quarter century) in making *billions* of metal powder parts, there seems to be no limit to our learning. Always there is something new to learn, something valuable to add to our already vast store of knowledge on the subject of powder metallurgy.

We find new ways to improve the physical properties of our metal powder parts; we see a constant broadening in the range of materials we can offer our customers; and the number of applications for our metal powder parts grows with our knowledge.

We're proud of the position we've reached in the field of powder metallurgy . . . but no prouder than we are of the way our products are able to serve industry by improving performance while cutting costs.

m

moraine products

DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO

ust 24, 1953, were based on appropriations approved by the 83rd Congress, 1st Session. These 1954 estimates are still tentative, since several agencies plan further revisions in their programs.

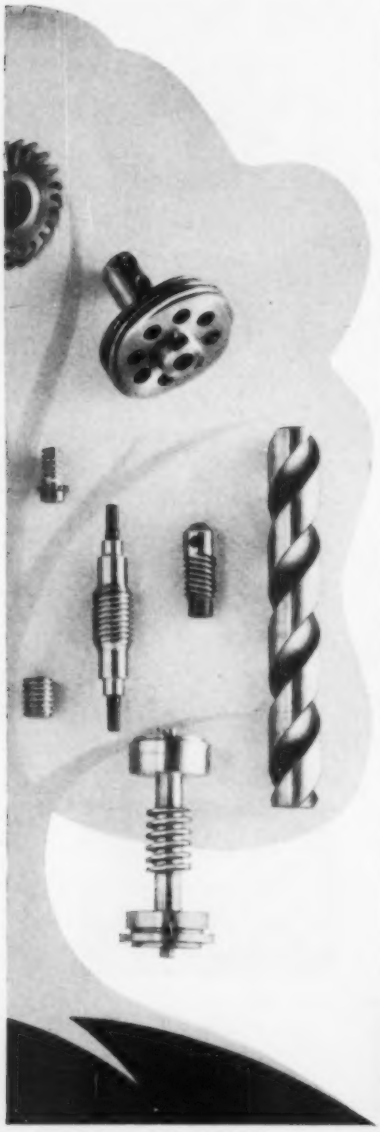
The Department of Defense estimates constitute the largest portion of the totals for both obligations and expenditures. Present figures indicate that in fiscal year 1954 the Department may obligate $1,556 million, including a carry-over of $142 million from previous years.

The statistics were compiled by the Foundation as part of its continuing study of the governments research and development activities.

British Alcladding

LONDON—The British Iron and Steel Research Association is still looking for a method for aluminum-cladding steel that English manufacturers can install without large capital expenditures. Companies are either unwilling or unable to buy the equipment necessary for cladding techniques currently in production in the United States. At present there's only one possibility on the horizon: a glycerol process that needs little capital equipment.

TITANIUM FORGING — largest ever made is this 100 in. long propeller blade forged at Ladish Company from titanium alloy Ti-140-A. Designed by the Hamilton Standard Division of United Aircraft for an Air Force research project, the blade was formed on the most powerful closed impression die forging hammer in the U. S. Ladish now claims they can make closed impression titanium forgings that weigh up to 10,000 pounds



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GROUND THREAD WORMS

SPIRAL BEVEL GEARS

QUAKER CITY GEAR WORKS INCORPORATED

BETHAYRES, PA. CHAPEL HILL 0800

A STRONG POINT with MARS— SAVE TIME AND MONEY

Sharpener in push-button head

Save considerable time, money and effort by using imported MARS-LUMOGRAPH products.

Whether you use 2886 MARS-LUMOGRAPH wood-cased pencils, or 1001 MARS-TECHNICO lead holders* with 1904 MARS-LUMOGRAPH rifled drawing leads, you have the product of 300 years' experience in superior pencil craftsmanship. See your dealer today.

*The 1001 MARS-TECHNICO has a sharpener concealed in the push-button cap, can be easily and completely disassembled and has individually replaceable parts.

Degree marking for easy identification

Leads in 18 degrees, rifled for perfect grip

Individual parts replaceable

SINCE 1662

J.S. STAEDTLER, INC.

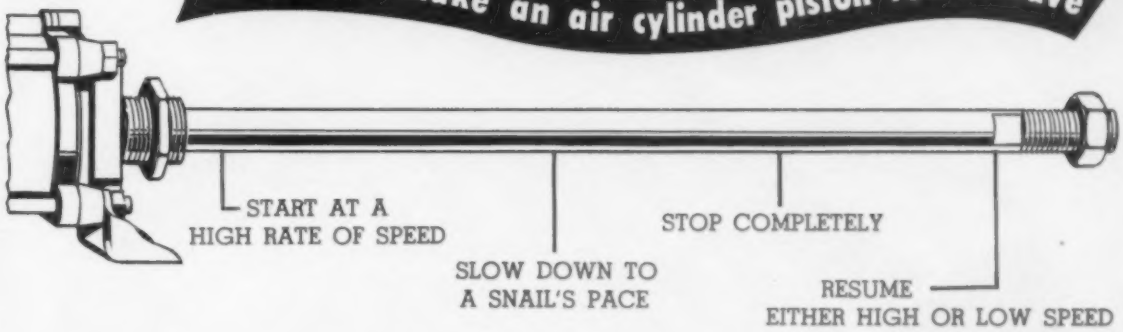
53-55 Worth Street

NEW YORK 13, N.Y.

MADE IN GERMANY

Skip CHECK — *Stop* CHECK

or how to make an air cylinder piston rod behave



Start an ordinary air cylinder and its natural tendency is to proceed at a fairly uniform rate to the full length of its stroke.

But with this "packaged" air cylinder power unit the piston rod can start its advance at a high rate of speed, slow to a snail's pace when you wish, stop completely at any desired point, and resume either a slow or high speed as you prefer.

Not all pneumatic applications require the range of piston rod speed control available in this model DCSTSBEM combination Bellows Air Motor and Hydro-Check, of course. But, regardless of the type of control you require, you can obtain it in Bellows Air Motors . . . and usually in the form of one compact, complete, "packaged" unit — simple to install, doubly simple to control.

sk your Local Bellows Field Engineer to show you the range of control ossibilities in Bellows Air Motors and Hydro-Checks — or write for a copy our new free 36-page bulletin. Ask for Bulletin CL-50. Address Dept. PE- The Bellows Co., Akron, Ohio. In Canada, Bellows Pneumatic Devices of , Ltd., Toronto. In California, The Bellows Co. of California, Los Angeles.

The Bellows Co.

AKRON 9, OHIO

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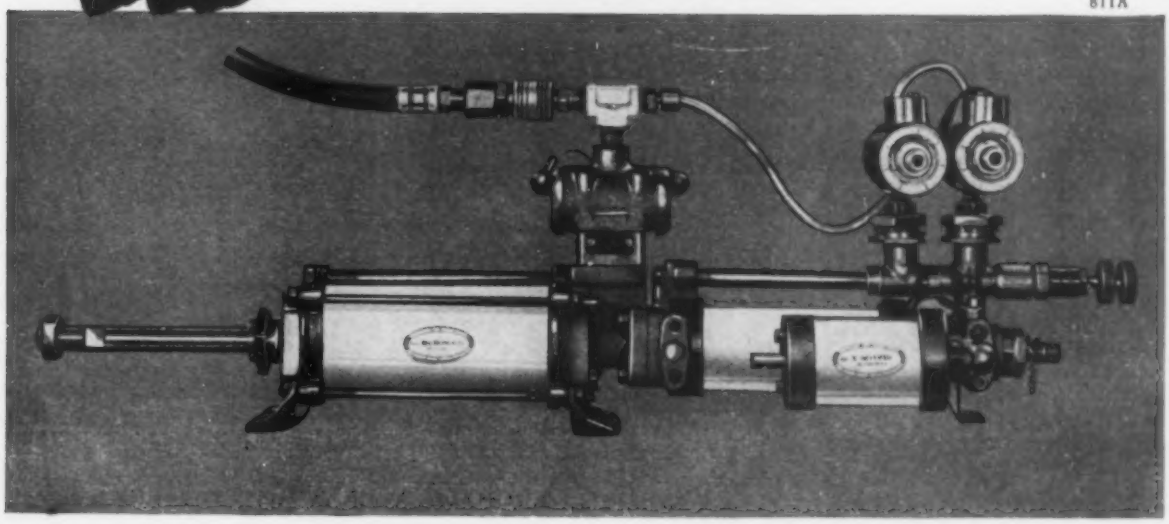

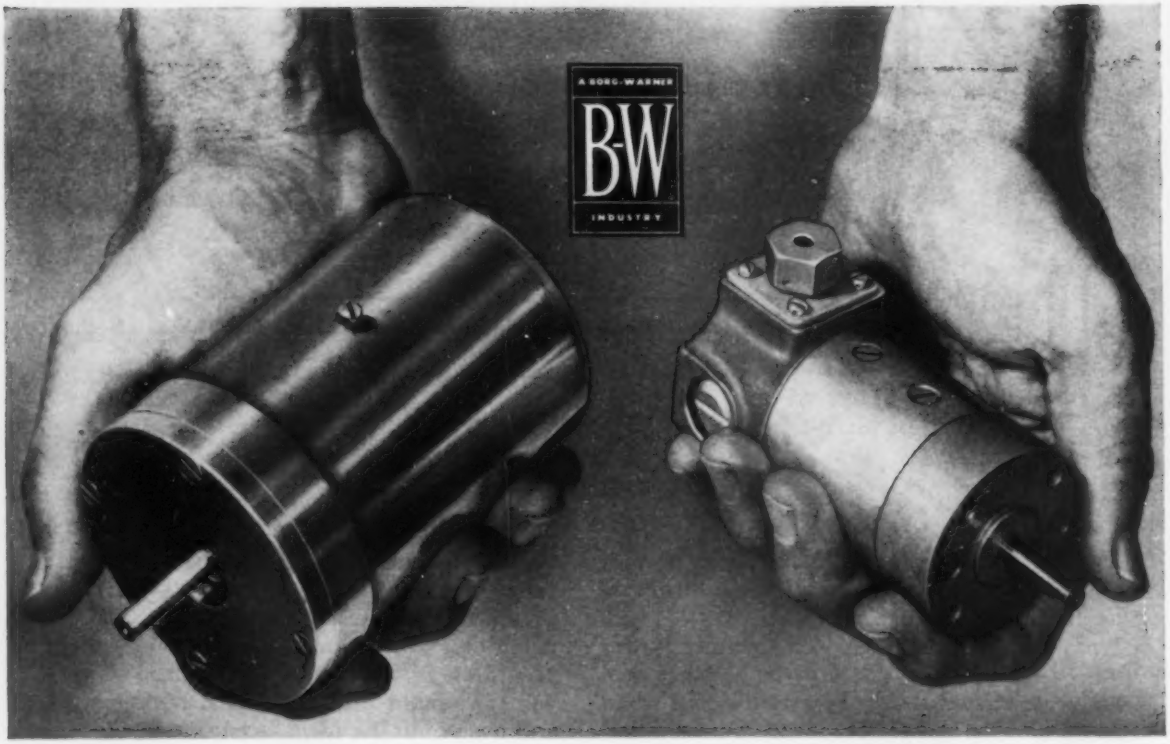

Compact, powerful, custom-built A.C. or D.C. motors for ELECTRONICS and ELECTRO-MECHANICS

Wherever you need electric motors for maximum power in minimum size, Pesco has the basic co-ordinated frame sizes and power elements you'll require.

For example—Pesco motors are now in use for: cooling (blowers for electronic equipment), tuning (radios and automatic finders), scanning antenna (civilian and military), antiaircraft radar fire control, as well as pump drives and mechanical actuators.

By using standardized parts in a series of six co-ordinated frame sizes, Pesco can provide you with electric motors for electronic applications with voltages from 6 to 120 volts D. C.; from 1/100 to 6 H. P. for operating speeds up to 15,000 R. P. M. Special, high-altitude design will operate from -65° to + 165° F.

Pesco high-frequency A.C. induction motors, squirrel-cage type, are built in a series of 5 co-ordinated frame sizes to meet horsepower requirements of .01 to 9.0, at 400 cycles per second.

Motors in these frame sizes can be built for *your* specific frequency, using standard parts to obtain the speed and power rating desired. Consult our Engineering Department concerning your requirements. Strictest confidence—and no obligation, of course!

engineering Pesco production

PRODUCTS DIVISION

BORG-WARNER CORPORATION

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CLARK
EQUIPMENT
CLARK
These rugged, precision-engineered Clark transmissions and drive units have the faculty for making powered farm machinery better . . . adding materially to its utility, ease of operation, dependable performance and useful life. Perhaps that's why so many manufacturers have long since learned that "it's good business to do business with CLARK."
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PRODUCTS OF CLARK — TRANSMISSIONS • AXLE HOUSINGS • TRACTOR UNITS • FORK TRUCKS and TOWING TRACTORS • ROSS CARRIERS • POWRWORKER HAND TRUCKS • POWER SHOVELS ELECTRIC STEEL CASTINGS • GEARS and FORGINGS • FRONT and REAR AXLES for TRUCKS and BUSES

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HOLTITE NYLOK SCREW

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ONE-PIECE SELF LOCKING SCREWS AND BOLT

HERE'S WHY HOLTITE-NYLOK LOCKS SECURELY

HOW NYLOK LOCKS
(Patented)
Resilient Nylon plug (A) sets up lateral thrust, smoothly wedging mating threads together (B). All of locking action is on the threads; head is not stressed. Locking is positive seated or unseated.

. . . SAVES YOU TIME AND MONEY!

Eliminates safety wire, lock washers, jam nuts, and all other locking devices.

The new Holtite-Nylok screws and bolts employ a nylon insert in the threaded section that provides a smooth, positive locking action. Seated or unseated, they lock where stopped.

. . . PLUS THESE EXTRA ADVANTAGES

- Positive Locking
- One piece; eliminates separate auxiliary parts
- Readily replaced
- Interchangeable
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- Locks seated or unseated
- Defies vibration
- No harm to mating thread of parts
- Acts as a seal for gases and liquids under high pressures

YOU CAN ALWAYS COUNT ON CONTINENTAL'S ENGINEERING SERVICE

As Holtite-NYLOK fasteners are presently intended for specific applications, our engineers welcome the opportunity to study your individual requirements and make recommendations for the most efficient and economical applications.

Why not check your own assemblies today. There's a good chance Holtite-NYLOK can boost your output, and save you money.

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HENRY C. JONES

Chief of Material for Convair's Fort Worth division. His supervision of over 800 people in this department includes responsibility for more than 45,000 items. Over $200,000,000 has been spent by his department during the B-36 production program.

CONVAIR

A Consolidated Vultee Aircraft Corporation, Fort Worth, Texas

May 7, 1953

Continental Screw Company
New Bedford, Massachusetts

Gentlemen:

At Convair's Fort Worth division, it is the practice to periodically review our 2,196 B-36 subcontractors and suppliers in 38 states.

Recently, we conducted a survey among fastener manufacturers to determine how they were meeting quality standards and delivery schedules. You will be glad to know that the following facts were developed concerning your company:

Screws, Hi-Shear rivets, and other fasteners made by Continental are used throughout the B-36 bomber in varied applications. Our quality control records indicate your screws and rivets have a very high quality rating. There have been no rejections because of faulty workmanship--a factor of supreme importance in this business of aircraft manufacturing.

Continental has been able to maintain deliveries in a very satisfactory manner despite the many difficulties encountered during the past several years. In shortage situations, Convair has been able to receive expedited shipments from you.

In the past year, Convair has been going direct to the manufacturer more and more for purchases on volume items. The direct purchases of both your screws and Hi-Shear rivets show a considerable increase in recent months.

I sincerely hope that the fine relationship between our companies will continue through the years.

Sincerely yours,

Henry C. Jones

Henry C. Jones
Chief of Material
Fort Worth Division

You too can count on Continental®

CONTINENTAL SCREW COMPANY INC. 1904

Manufacturers of HOLTITE Fastenings For Every Purpose

CONTINENTAL SCREW COMPANY, NEW BEDFORD, MASS., U.S.A.

• *Standard steel's unsurpassed ability to produce weldless rings all the way up to 144" O.D. is one of SIX REASONS WHY YOU SHOULD ALWAYS CALL STANDARD STEEL FOR RINGS AND FLANGES:*

Weldless Rings from 12" O.D. to 144" O.D.

1. TESTING—radiographic tests, tensile tests, hardness tests, ultrasonic probing of internal structure, etc.

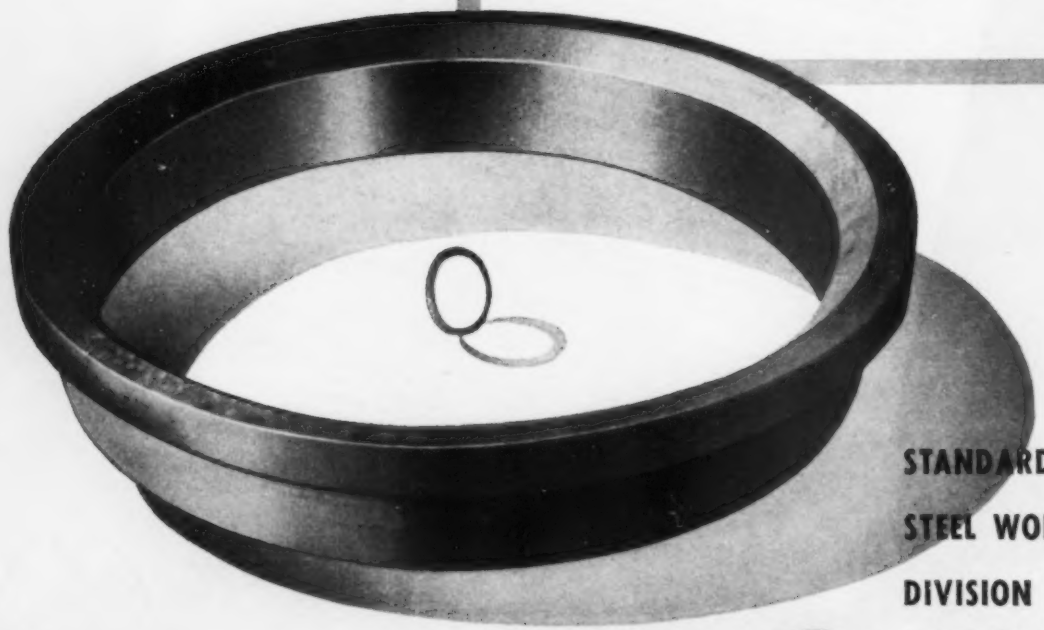
2. QUALITY STEEL—through production of own steel by the acid open hearth process.

3. UNIFORMITY—assured by precise control of forging and rolling operations.

4. CAPACITY—unsurpassed ability to produce weldless rings all the way up to 144" O.D.

5. EXPERIENCE—produced by skilled workmen with 20 to 40 years experience.

6. FAST SERVICE—a vital factor in the continuing growth of Standard Steel for over 150 years.



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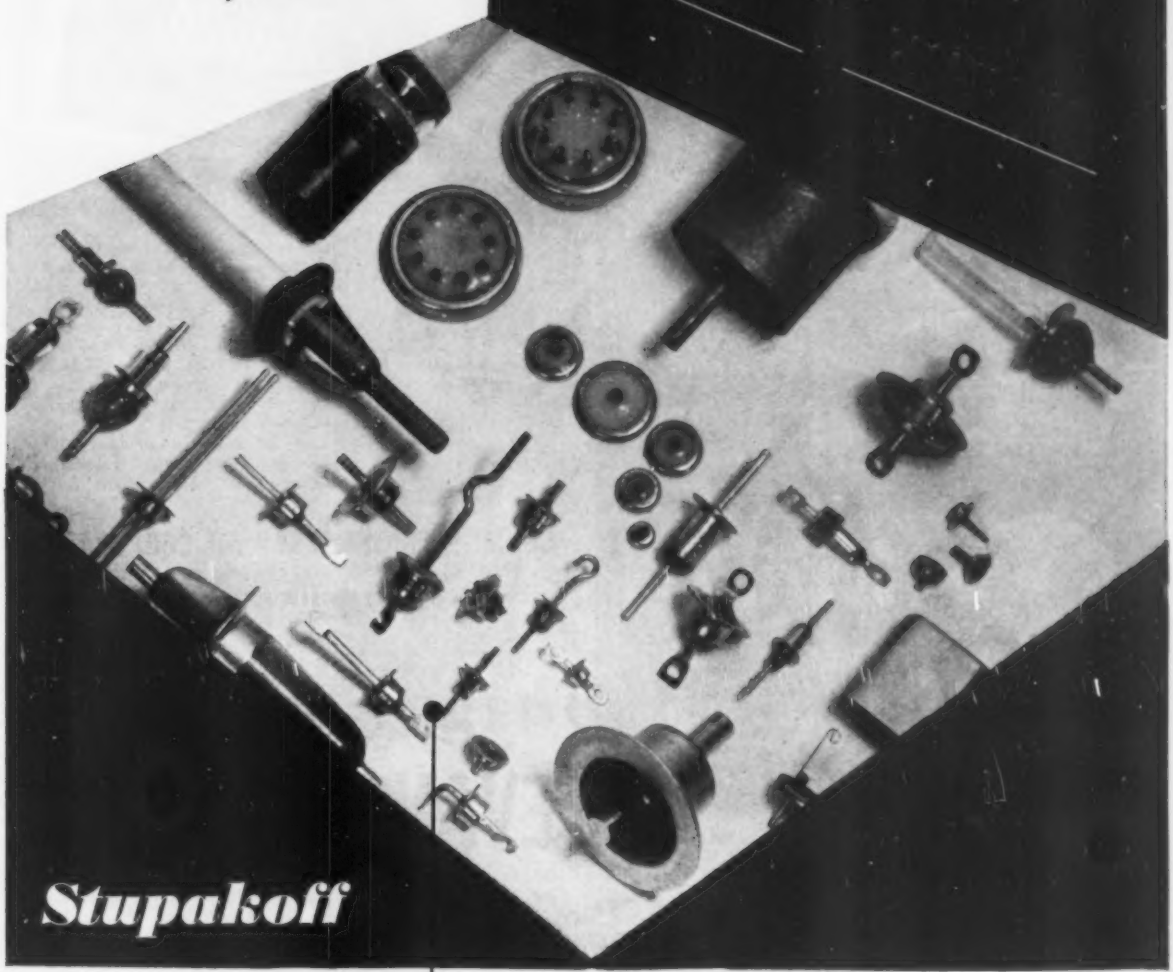
General Offices: Philadelphia 42, Pa. Offices in Principal Cities

for durable and dependable



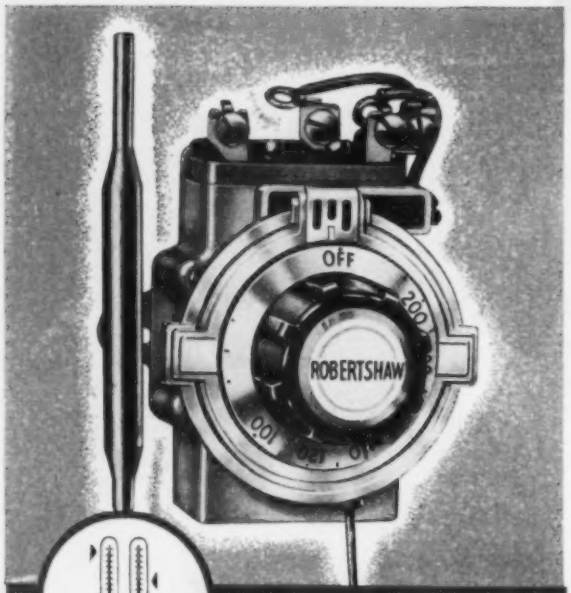
glass-to-metal seals

A complete range of sizes and designs of terminals, lead-ins and stand-offs for hermetic sealing is offered by Stupakoff. Made with Kovar metal, the ideal alloy for sealing to hard glass, Stupakoff Seals are durable and dependable. These are not mechanical compression seals, but are permanently fused by chemical interaction. They may be installed by conventional assembly techniques.

Write for a copy of the new Stupakoff Catalog 453, giving details of over a thousand sizes and styles of Stupakoff Seals.

STUPAKOFF CERAMIC & MANUFACTURING COMPANY

LATROBE, PENNSYLVANIA



HI-HEAT TO LOW HEAT

BLOWER AND HEATER

AGITATOR AND HEATER

SWITCHING
HEATING CIRCUITS
CUTTING IN
MOTOR or BLOWER

Robertshaw®

MODEL F-1

2 Circuit Thermostat

The Model F-1 shown here is a single pole, double throw thermostat used to switch circuits from high to low heat where two heating elements are used. For example, an appliance may have one heating element with 4500 watt capacity and a heat holding element with 1000 watt capacity. When the thermostat calls for heat, the 4500 watt element is in action. When the desired temperature is reached, the main contacts are broken, the low heat element is cut in and the 1000 watt element will function until a drop in the temperature causes the thermostat to operate and switch contacts back to the 4500 watt element.

May be used to operate fans in air duct or agitators in tank, etc., in combination with heaters when desired. *Write for Catalog.*

Robertshaw-Fulton CONTROLS COMPANY

ROBERTSHAW THERMOSTAT DIVISION, YOUNGWOOD, PENNSYLVANIA

FOR NAME PLATES THAT REFLECT

Quality

WRITE FOR THIS BOOKLET

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Write for "Etched or Lithographed Metal Products of Quality," with full color examples of our name and instruction plates.

CHICAGO THRIFT-ETCHING CORPORATION

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SUBSIDIARY OF DODGE MANUFACTURING CORPORATION, MISHAWAKA, INDIANA

Always Specify

EVANS' SPRINGS

FOR *Precision*

FOR *Performance*

COMPRESSION • TORSION
EXTENSION & SPECIAL
TYPE SPRINGS
METAL STAMPINGS &
WIRE FORMS

SEND FOR SPECIFICATION SHEET FOR EASY ORDERING

JOHN EVANS' SONS, INC.

506 NORTH 13th STREET
PHILADELPHIA 23, PA.

FOR DESIGN ENGINEERS

GEAR REDUCTION UNITS

- SPACE SAVING
- DESIGN FLEXIBILITY
- HIGH OVERHUNG LOAD CAPACITY
- DUST-PROOF, OIL-TIGHT OPERATION
- CUSTOM-ENGINEERING SERVICE

DESIGNERS AND SUPPLIERS

Double Reduction
Right Angle
Parallel Shaft
Shaft Mounted
Speed Reducers and Gearmotors

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Get This New Catalog containing features, sizes, ratios, mountings, H.P. ratings, and specifications. Rynel offers a complete range of Speed Reducers and Gearmotors for custom-designing your particular applications.

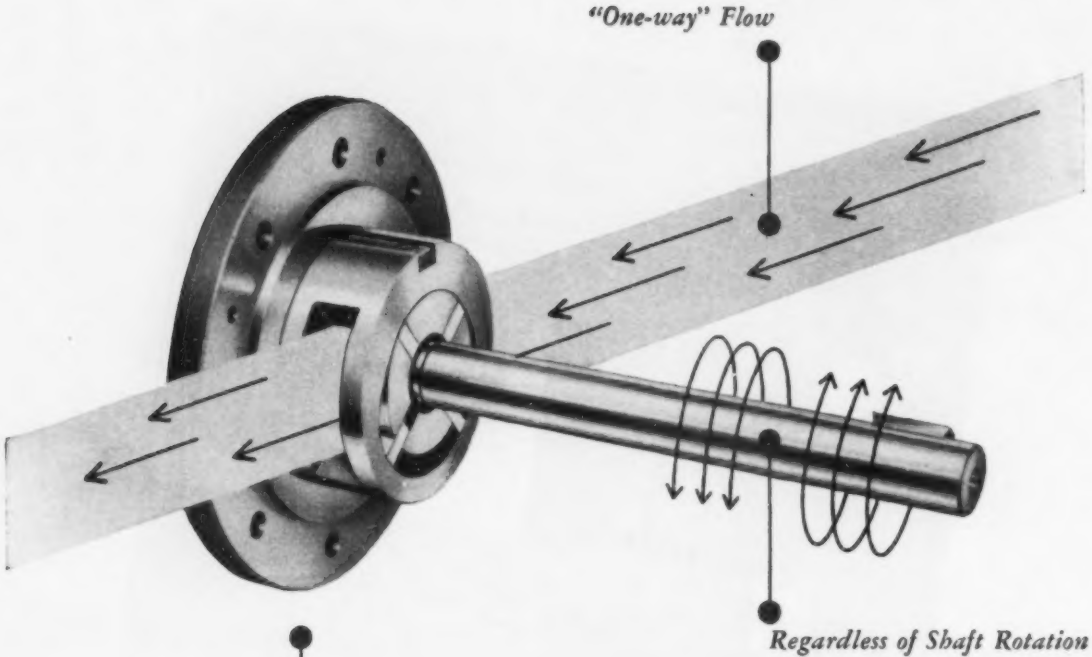
With Rynel's exclusive Air Service, you can solve your power reduction problems overnight, with units exactly suited to your job requirements.

TELEPHONE A RYNEL ENGINEER — Sterling 4440
He Will Visit You The Same Day You Call.

YOUR COPY FREE — Ask for your free copy of this new Catalog describing the Design-Flexibility obtained with the interchangeability of Rynel Power Reduction Units. Specify Catalog No 712.

712 Miller Street • Sterling, Illinois

CORPORATION



compact
versatile
convenient

automatic reversing vane pumps

You can make these extremely compact pumps an integral part of your machines or mechanisms which reverse. They're fully automatic reversing . . . discharge in one direction, supplying lubricant or coolant continuously regardless of shaft rotation. Direction of discharge changed easily in field.

Brown & Sharpe Automatic Reversing Vane Pumps in *Stripped Models without housing* shown here (Nos. 8023, 8063, and 8103) offer minimum projection from machine surfaces . . . are designed for use when suction and discharge ports can be incorporated in machine castings. *Stripped Models with housings* (Nos. 8022, 8062, and 8102) are easily installed when ports cannot be designed into machine, or when outside piping is desirable. *Complete Pumps* (Nos. 8021, 8061, and 8101) are also available. Sizes available: 2½, 5 and 11½ gpm at 0 lbs. pressure and at 1140 rpm. Features fully described in Bulletin. Write Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.

Buy through your local Distributor.

Brown & Sharpe B·S

DO *Your Products* FIT INTO THIS PICTURE?

Metal stampings have been the specialty of G. P. & F. for over 73 years. The illustrations above show just a few typical examples of contract parts we make for hundreds of customers. If you use deep drawn or stamped metal parts in your products, the chances are good that we have the facilities to meet your requirements. When you think of G. P. & F., think of over 1000 skilled people ... 15 acres of production facilities ... 293 deep draw and stamping presses ... 97 welding machines ... and a complete tool and die department.

G.P.&F.

Stamping • Drawing • Forming
Galvanizing • Welding
Lead Coating • Spray Finishing
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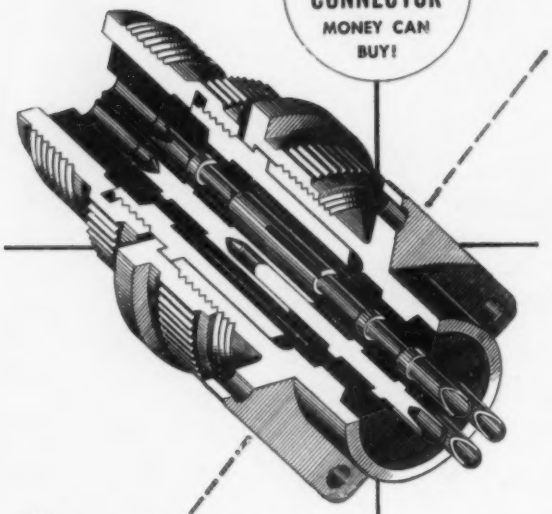
GEUDER, PAESCHKE & FREY CO., 1505 W. St. Paul Ave., Milwaukee 1, Wis.

The Finest
ELECTRICAL CONNECTOR MONEY CAN BUY!



SCINFLEX

ASSURES YOU THE LOWEST VOLTAGE DROP IN THE INDUSTRY!

When operating conditions demand an electrical connector that will stand up under the most rugged requirements, always choose Bendix Scinflex Electrical Connectors. The insert material, an exclusive Bendix development, is one of our contributions to the electrical connector industry. The dielectric strength remains well above requirements within the temperature range of −67°F to +275°F. It makes possible a design increasing resistance to flashover and creepage. It withstands maximum conditions of current and voltage without breakdown. But that is only part of the story. It's also the reason why they are vibration-proof and moisture-proof. So, naturally, it pays to specify Bendix Scinflex Connectors and get this extra protection. Our sales department will be glad to furnish complete information on request.

• Moisture-Proof • Radio Quiet • Single Piece Inserts • Vibration-Proof • Light Weight • High Insulation Resistance • High Resistance to Fuels and Oils • Fungus Resistant • Easy Assembly and Disassembly • Fewer Parts than any other Connector • No additional solder required.

BENDIX SCINFLEX
ELECTRICAL CONNECTORS

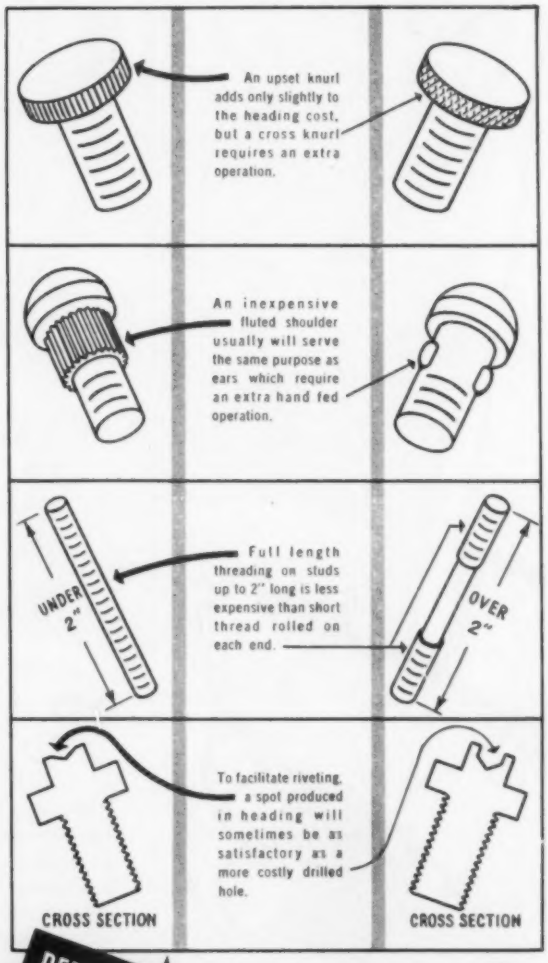
Bendix

SCINTILLA MAGNETO DIVISION of Bendix
AVIATION CORPORATION
SIDNEY, NEW YORK

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.
FACTORY BRANCH OFFICES: 117 E. Providencia Ave., Burbank, Calif. • Stephenson Bldg., 6560 Cass Ave., Detroit 2, Michigan • Brouwer Bldg., 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 582 Market Street, San Francisco 4, California.

STILL MORE WAYS TO
SQUEEZE PENNIES
OUT OF
UPSET SPECIALS COSTS

Specially designed upset products are solving thousands of problems. Dozens of design pointers on them are yours for the asking. Send us your sketches, prints, finished products for suggestions.


An upset knurl adds only slightly to the heading cost, but a cross knurl requires an extra operation.
An inexpensive fluted shoulder usually will serve the same purpose as ears which require an extra hand fed operation.
UNDER 2"
Full length threading on studs up to 2" long is less expensive than short thread rolled on each end.
OVER 2"
To facilitate riveting, a spot produced in heading will sometimes be as satisfactory as a more costly drilled hole.
CROSS SECTION
CROSS SECTION

REPRINTS *of this and of previously published charts are available on request for use in drafting and purchasing departments.*

QUALITY PROMCO BRAND

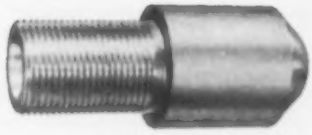
MACHINE SCREWS AND SPECIAL FASTENERS ARE OUR BUSINESS

WRITE FOR OUR CATALOG

THE PROGRESSIVE MANUFACTURING COMPANY
48 NORWOOD ST., TORRINGTON, CONN.

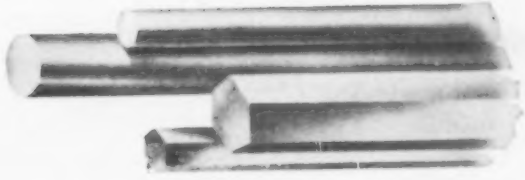
35% SAVING REPORTED

on this screw machine part



by switching from steel

to Kaiser Aluminum



Mr. Ken Lemke, Lakeview Screw Machine Company, Chicago, reports: "By switching from steel to an improved design in aluminum for a swivel part we manufacture we cut our machine time by two-thirds.

"This means we can pass on to our customer a saving of approximately *35% per thousand pieces!* We use the extra machine time to turn out more jobs, which means more business for us.

"We've also converted several jobs from brass to aluminum to give our customers the advantage of aluminum's lower material cost. By re-designing our tools we machine at the same rate as brass. And we find the aluminum parts highly satisfactory."

Kaiser Aluminum screw machine stock is free machining; provides big raw material cost savings over other non-ferrous metals; can assure better parts because of its unique combination of properties.

Important suggestion for product designers! Be sure to request an alternate bid in aluminum with each bid you request in another material. This is the easy and logical way to compare both price and suitability of the materials. You'll find that aluminum usually will greatly reduce your per-piece cost and can give you a better part at the same time.

Call in a Kaiser Aluminum engineer. He'll gladly give experienced assistance with alloy selection, design considerations, production techniques. Prompt deliveries of round and hexagonal aluminum screw machine stock now being made by us and our distributors.

Look for our local number in the classified telephone directory under the heading "Aluminum." Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif.

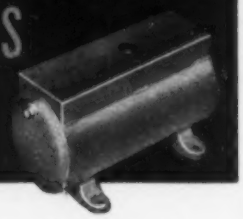
Kaiser Aluminum

setting the pace—in growth, quality and service

From any angle

SCAIFE PRESSURE VESSELS

are your best buy



Take air compressor tanks for example:

COST Modern equipment and advanced production techniques provide Scaife Company customers with quality pressure vessels at the *right* price . . . a price that helps you hold down the cost of the equipment you manufacture.

EFFICIENCY Scaife engineering skill and ingenuity plus continuous research are available to work for you in supplying the most efficient pressure vessel for your application . . . a vessel from Scaife's broad line of standard units that fits exactly the operating standards of the equipment you manufacture.

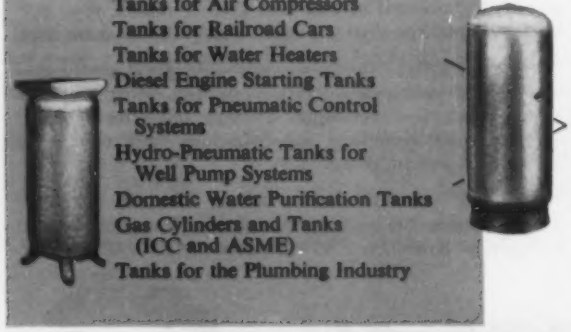
UNIFORMITY Rigid quality control practices are carried on throughout every step in the manufacture of Scaife pressure vessels. The result—volume production of uniform, quality cylinders and tanks precisely to the customer's specification.

DEPENDABILITY A history of more than 150 years of continuous operation provides evidence that Scaife Company has proved itself a dependable source of supply.

Whether you require ASME Code, ICC, other code or non-code pressure vessels, for air, water or gases, Scaife Company is qualified to serve you. Send for more complete information on Scaife Pressure Vessels today.

Typical Uses For Scaife Pressure Vessels

Tanks for Air Compressors
Tanks for Railroad Cars
Tanks for Water Heaters
Diesel Engine Starting Tanks
Tanks for Pneumatic Control Systems
Hydro-Pneumatic Tanks for Well Pump Systems
Domestic Water Purification Tanks
Gas Cylinders and Tanks (ICC and ASME)
Tanks for the Plumbing Industry



FOUNDED 1902

SCAIFE COMPANY

OAKMONT (PITTSBURGH DISTRICT) PENNA.

MAKERS OF PRESSURE VESSELS AND DRAWN SHAPES

DUTCH BRAND

Insulating Foursome

Your choice . . .

from a quality group . . .

to meet your exact requirements

1. DUTCH BRAND FRICTION TAPE

DUTCH BRAND Friction Tape is a quality product known to the trade for over forty years. It does not ravel . . . is free of pin holes . . . has correct adhesion . . . has long life and stands up on the job. Dielectric strength is 2000 volts for a single thickness.

2. DUTCH BRAND PLASTIC TAPE

Years of experience manufacturing tape for the electrical field are responsible for this outstanding product. It is thin . . . with 150% stretch. It resists weather, oils, acids and corrosive chemicals. Dielectric strength averages 1000 volts per mil of thickness. Available in regular .007" thickness or heavy duty .010" thickness for heavy duty work and for use with power driven tape machines. Be sure you get quality . . . get DUTCH BRAND Plastic Tape the next time you order.

3. DUTCH BRAND RUBBER INSULATING TAPE

DUTCH BRAND Rubber Insulating Tape resists up to 18,000 volts through a single thickness. It fuses instantly without heat . . . contains no corrosive chemicals . . . has long life and is dependable. This tape serves a very definite unreplaceable service under electrical codes in meeting many electrical insulating requirements. Available at your electrical wholesalers . . . order a supply today.

4. "DB" WIRE CONNECTORS

"DB" Wire Connectors are quality products made to exacting specifications and design. They are designed with long skirt for full insulating protection . . . made of phenolic material, they are weatherproof . . . vibration proof and resist pull-out. Knurled design makes them easy to handle and apply. Available in four standard sizes. The next time you order DUTCH BRAND electrical tape also order your supply of "DB" Wire Connectors.

ORDER FROM YOUR ELECTRICAL WHOLESALER

DUTCH BRAND

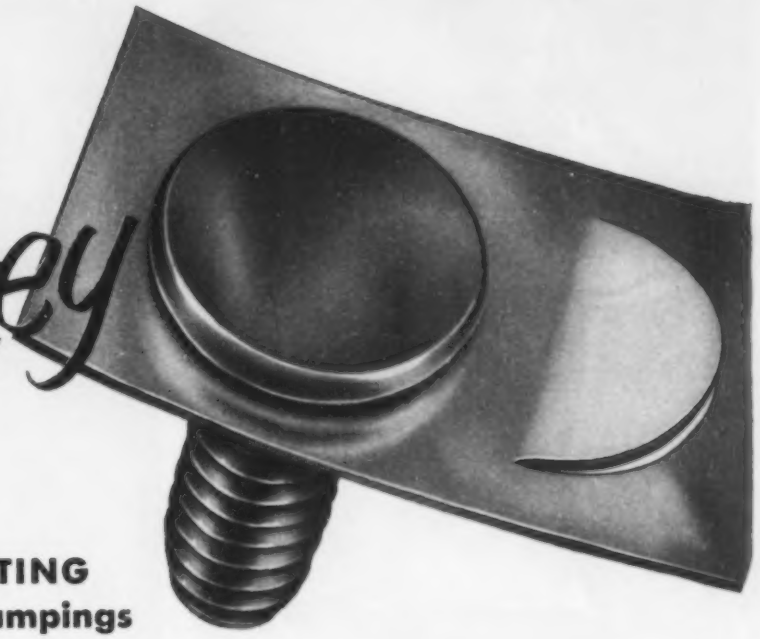
VAN CLEEF BROS. INC.

Manufacturers of Rubber Products

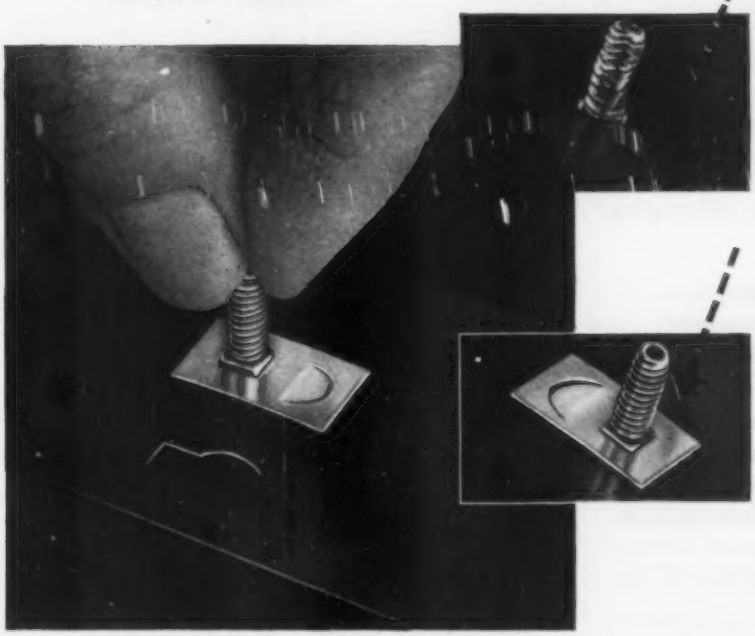
DIVISION OF Johns-Manville

7800 WOODLAWN AVE. • CHICAGO 19, ILLINOIS

NEW Quickey FASTENER



- **FACILITATES NESTING of sheet metal stampings**
- **ELIMINATES DAMAGE due to welded or staked studs**



Not this

Welded or staked studs are easily damaged in transit from one department to the next or during processing, painting, polishing, etc. The bolts themselves can cause serious damage, denting, scratching or chipping painted or polished surfaces.

But this

QUICKEY SNAPS IN just before final assembly . . . allows finished parts to be nested for economical transportation *without* protruding studs of any kind. Installed at the last moment, every Quickey is perfect. If damaged during later assembly operations, any Quickey can be removed and replaced easily and quickly, even in blind assemblies.

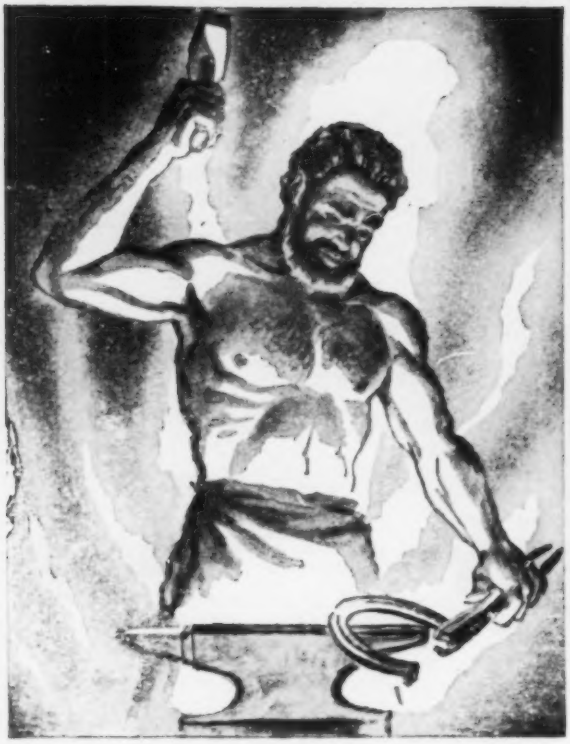
•

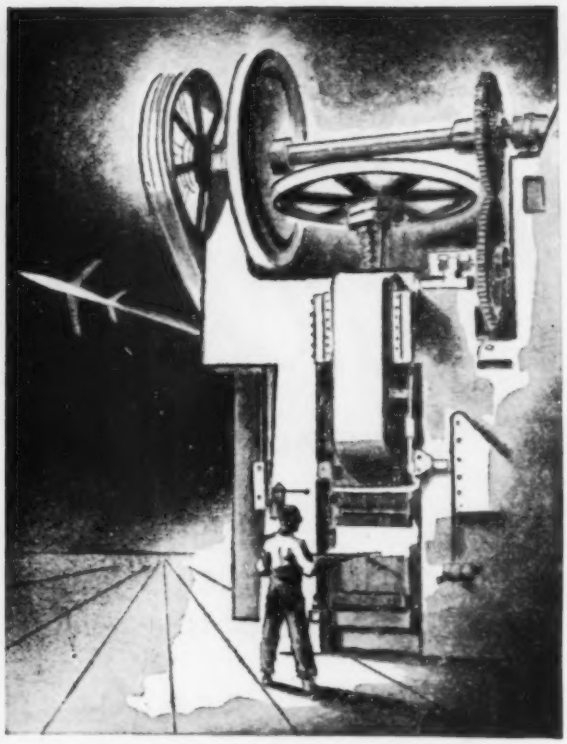
UNITED-CARR

MAKERS OF DOT FASTENERS

Like thousands of other fasteners and allied devices, designed and manufactured by United-Carr, Quickey helps speed assembly and cut costs. Available in a complete range of sizes and in volume quantities; further details on request.

UNITED-CARR FASTENER CORPORATION, CAMBRIDGE 42, MASSACHUSETTS





FORGING COMES OF AGE...JET AGE!

From horse-shoe to jet engine blade is an air-age away. Both are forged – but there the similarity ends. For UTICA's new methods of forging, with giant new machines and a world of new forging knowledge, combine to ring out results that would leave an old-style smithy gasping.

All the advantages of forging — at accuracies of a few thousandths!

Today's forging brings out the toughness, the strength of the metal – concentrates the strength where it's needed – yet ends with a finished part within a few thousandths of final size. Drastically reduces machining time and cost. Gives you a part that's minimum weight and dependable as only forgings can be! More than that, with UTICA's precise quality control system, you get accurately forged pieces by the thousands!

UTICA forging techniques for both "old" and "new" metals.

Today, as for many years, UTICA forges are producing our own fine alloy steel pliers and adjustable wrenches. And, with new techniques – many of them pioneered here – we are forging jet engine blades and other critical parts from the new, hard-to-handle metals. Perhaps we can help you – with small, precise forgings for defense today . . . with forgings for new products tomorrow.

Jobs available for technically trained personnel.

Our new "File Facts on Precision Forgings" outlines UTICA's methods and facilities for precision forging, now totally engaged in jet blade production, but ultimately generally available.

PRECISION····U TI CA····FORGINGS

TRADE MARK

UTICA DROP FORGE & TOOL CORPORATION

UTICA 4, NEW YORK

MAKERS OF THE FAMOUS UTICA LINE OF DROP FORGED PLIERS AND ADJUSTABLE WRENCHES

Samson Chairs by Shwayder Bros., Inc. Col-O-Vin vinyl upholstery of Marvinol resin by Columbus Coated Fabrics Corp.

"Strong enough to stand on!"

Tough enough, too–with Marvinol!

Seats should be sat on, of course. But little Susie won't harm these rugged Samson chairs! Shwayder Brothers–one of the world's largest manufacturers of folding chairs for public seating–makes them strong enough to stand on! And covers them with super-tough Col-O-Vin upholstery made from Marvinol resin by Columbus Coated Fabrics–a leader in the field of vinyl sheeting.

So practical, this vinyl upholstery is unharmed by all-day-suckers, greasy hands, disinfectants, or even the weather. Maintenance is almost nil–vinyl upholstery made from Marvinol *cleans with a wipe.* It resists acids, alkalies, most chemicals. And it passes the strictest fire codes for flame resistance.

Beautiful, too. In deep, rich tones, or delicate pastels, Marvinol permits built-in color styling–lasting as the material itself.

So tough, this vinyl covering produced from Marvinol resins will last long after Susie finishes school. It has excellent strength –won't tear or scuff–won't dry out, craze, or crack no matter how many "Susies" it meets.

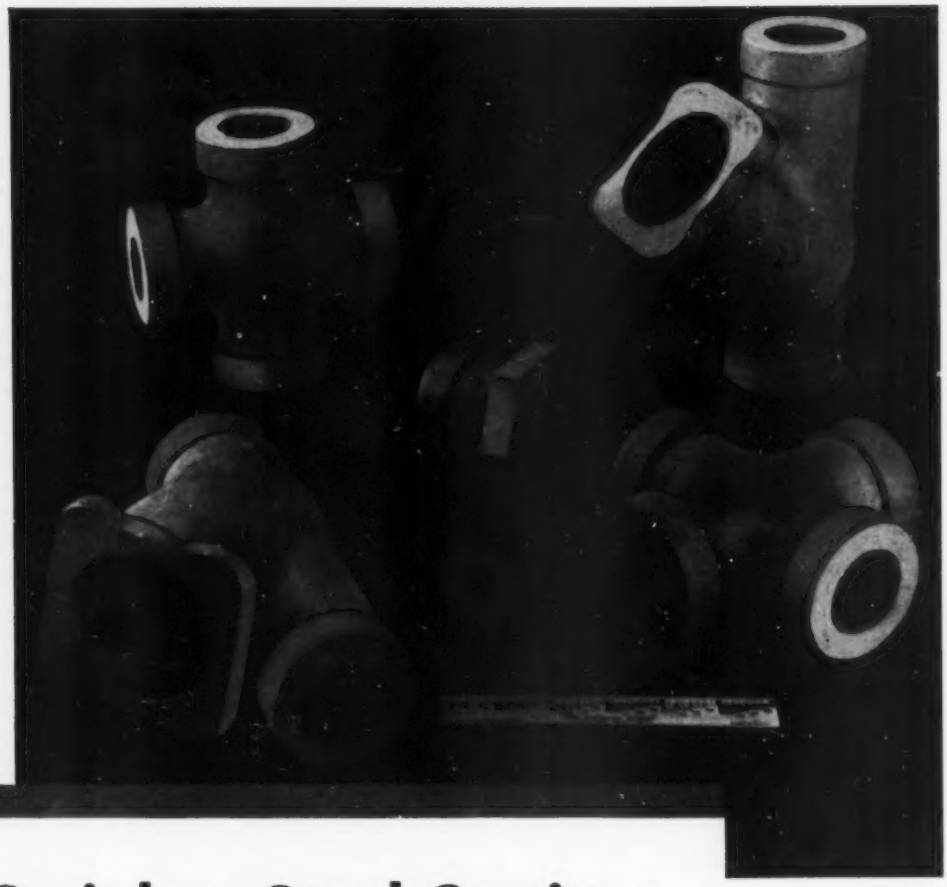
Can Marvinol® help you? Readily calendered, extruded, molded, or laminated, it can be formed into film and sheeting, foamed shapes, belting, pipe, floor tile, and a wide variety of other products.

Naugatuck technical sales representatives will be glad to help you work out your particular product problem. For more information on this partner to Naugatuck's VIBRIN® polyesters and KRALASTIC® rubber-resin blends, write on your letterhead to address below.

Naugatuck Chemical

Division of **UNITED STATES RUBBER COMPANY** • 200 Elm Street, Naugatuck, Conn.

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis
New York • Philadelphia **IN CANADA:** Naugatuck Chemicals, Elmira, Ontario



AL Stainless Steel Castings meet any need for Cleanliness

Here's New Data on
ALLEGHENY METAL
in Various Industries

Available *now*—informative booklets on Allegheny Metal in the Chemical, Petroleum Refining, Brewing, Meat Packing, Dairy, Food Processing, Hospital and Laundry Industries—others in preparation. Write for this valuable data on the field in which you are interested.

ADDRESS DEPT. PE-46

Note the clean, sound, fine-grained appearance of the Allegheny Metal sanitary fittings shown above, in the "as-cast" condition. They're typical of the wide variety of stainless steel castings we produce for the chemical processing, food, dairy, beverage, oil, paper and textile industries, etc.—wherever the purity and quality of products must be maintained, and where ease of sanitation and assurance of long, trouble-free service are prime considerations.

Allegheny Metal castings are produced by methods specially developed to protect uniform quality and guard against defects. You'll find them superior both from the standpoint of machinability and soundness. ● Let us quote on your stainless casting requirements—any shape and any size, from a few ounces to 5000 pounds. *Allegheny Ludlum Steel Corporation, Henry W. Oliver Bldg., Pittsburgh 22, Pa.*

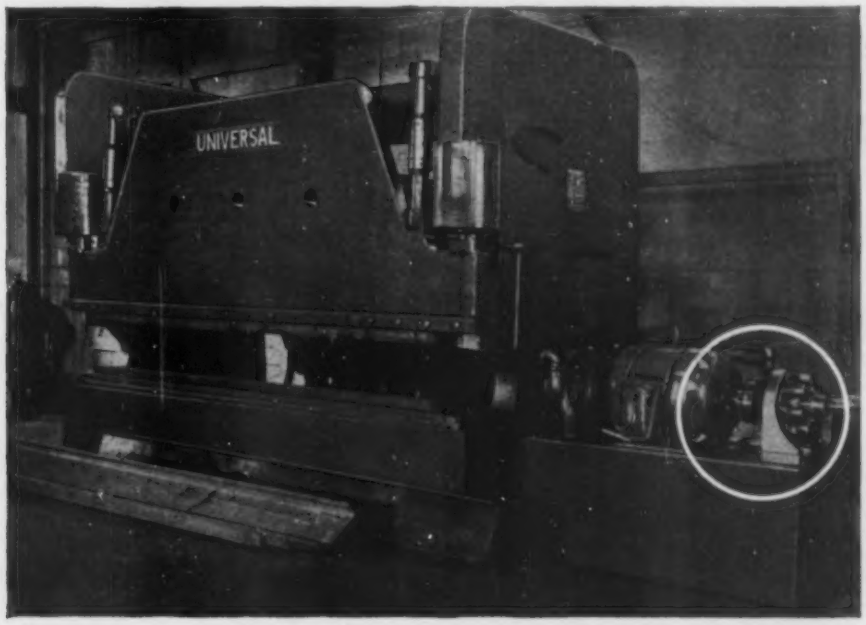
You can make it **BETTER** with

Allegheny Metal

W&D 4440

AL TIME-TESTED STAINLESS STEEL

WHEN IT'S HIGH PRESSURE IT'S AMERICAN!



Metallic sheets are "putty" to this machine...powered by a HYDRAMITE

BENDING, FORMING, PIERCING, corrugating or braking sheets of metal up to ½ inch thick! That's the year in, year out job of the 10-foot, 300-ton Hydraulic Press Brake made by Universal Machine Company. And to assure economical, completely dependable power, Universal has adopted the American Engineering Hydramite fluid power pump as standard equipment.

Hydramite is a radial multi-piston, constant displacement, oil-operated pressure generator. It maintains pressures up to 5000 p.s.i. . . . is direct-driven through a flexible coupling . . . rotates in either direction. No supercharging is required. And Hydramite can be foot, flange or face mounted . . . it is exceptionally quiet . . . has overall efficiency of 85%.

Your American Engineering representative is thoroughly qualified to analyze your hydraulic requirements, install the necessary power units and assume full responsibility *locally* for continuous, efficient service. Mail coupon for complete data.

HELE-SHAW
variable pressures up to 3000 p.s.i.

Hele-Shaw is a radial-piston variable displacement fluid power generator. Pressure and reversal of flow are controlled directly at the pump. Discharge can be varied from zero to maximum . . . and reversed gradually or instantly. Suitable controls available. Capacities from 0.5 to 53 g.p.m. and up.

AMERICAN ENGINEERING
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PHILADELPHIA 25, PENNA.

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AE Products are: Taylor and Perfect Spread Stokers, Marine Deck Auxiliaries, Hele-Shaw and Hydramite Fluid Power, Lo-Hed Hoists, Lo-Hed Car Pullers.

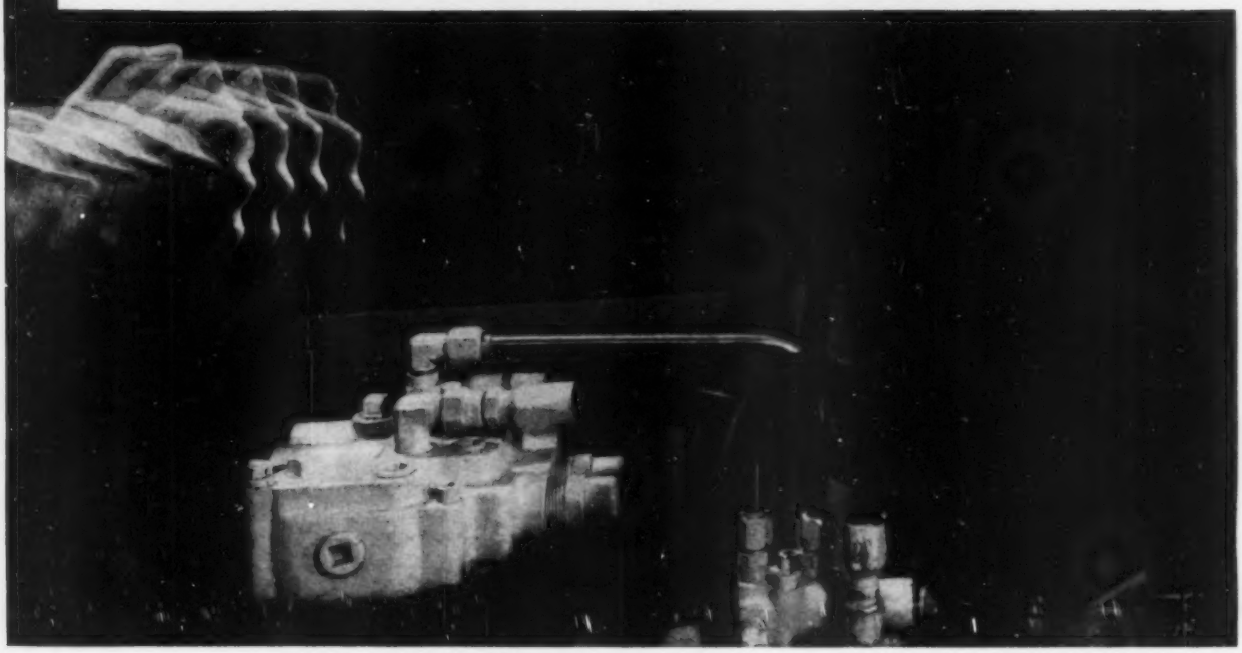
American Engineering Company
2501 Aramingo Avenue, Philadelphia 25, Pa.

Gentlemen: Kindly send me complete information about the
☐ Hele-Shaw Pump. ☐ Hydramite.

Name.....Title.....
Company.....
Address.....
City.....Zone.....State.....

NO JERKS, NO JIGGLES...

New Parker mobile-equipment valve positions a load gently and exactly



Special lift truck demonstrates gentle, exact control of new valve. Stop-action photo

Parker announces a new line of directional-control valves for mobile-equipment applications . . . lift trucks, agricultural machinery, and earth-moving equipment. These valves provide gentler and more exact positioning control than any other. Here's how:

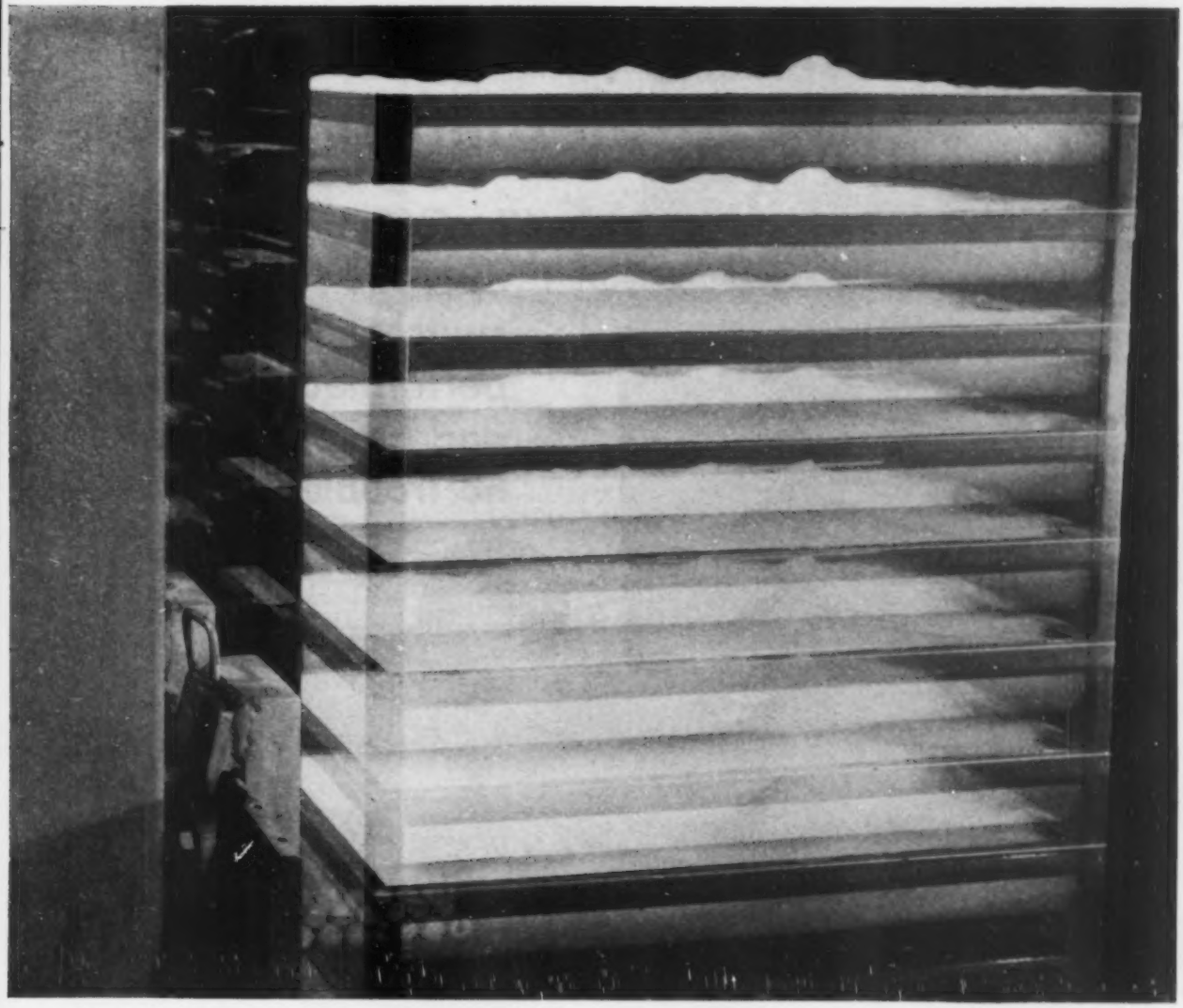
The new valve has full feathering on both open-center and cylinder ports. This feathering is especially good for two reasons. First, a load check eliminates dead spots and back flow to the pump. Second, unique spool notches provide sensitive rate-of-flow control during crossover. A full parallel circuit enables you to do several operations at once.

These new Parker valves are offered in 1, 2, 3, or 4-spool designs, with capacities up to 35 gpm. Flow characteristics can be tailored to your specific applications. For instance, the valve has a built-in carry-over for piping from one valve to another without pressurizing seals. You can add additional functions in this way.

Both designers and salesmen will be enthusiastic about the many other features and benefits. Why not call in Parker today? We would like to discuss these valves in detail . . . and work with you in developing their proper application on your equipment.

INDUSTRIAL HYDRAULICS DIVISION
The Parker Appliance Company
17325 Euclid Avenue, Cleveland 12, Ohio

Parker
Hydraulic and fluid system components



shows tank of soapy water (suds on top) being raised without a ripple in the water line.

What other Parker products for hydraulic and fluid systems interest you? Triple-lok flare fittings? Ferulok flareless fittings? Synthetic rubber O-rings? Any other products?

THE PARKER APPLIANCE COMPANY
Section 201-L
17325 Euclid Avenue
Cleveland 12, Ohio

Please send me the following information:

☐ Hydraulic control valve Bulletin 1551 A
☐ Information about these other Parker products:

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

Send for catalog of complete information about Parker hydraulic control valves. If you'd like to know more about other Parker products, list them on the coupon or write to the above address.

Another Ingenious

"In 5½ years of field operation Acro switches have performed very well and have given us no trouble"

M. A. GREGORY, Manager of Quality Control, Seeburg Corporation, Chicago, Ill. points to Acro switch in record player.

MAKE YOUR UNRESTRICTED CHOICE FROM

COIN SWITCHES OPEN BLADES PHENOLIC ENCLOSED METAL CLAD MINIATURES

and Economical Application for

ACRO *SNAP ACTION* SWITCHES

When you put multiples of coins into a remote control wall box of the Seeburg "Select-O-Matic," a "credit" is automatically established. This entitles you to hear the number of plays you pay for in advance. You can pre-select your favorites from any of 100 recordings.

There is an ingenious system of electric controls back of the smooth, effortless action that causes the music to pour forth. Actuating these circuits and guarding performance are simple, positive Acro snap action switches.

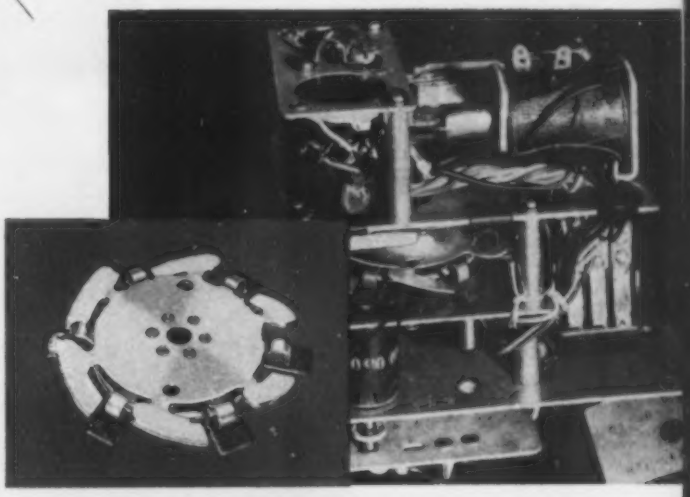
For example, consider the Credit Cancel Unit. Here, Acro and Seeburg engineers combined their talents to design a circular arrangement of six economical open blade Acro switches operating on a pressure of only 35 to 50 grams.

And the "Select-O-Matic" mechanism is controlled by a single Acro Model M switch. It's the key operating unit on a three wire circuit which does the entire job of making 100 record selections.

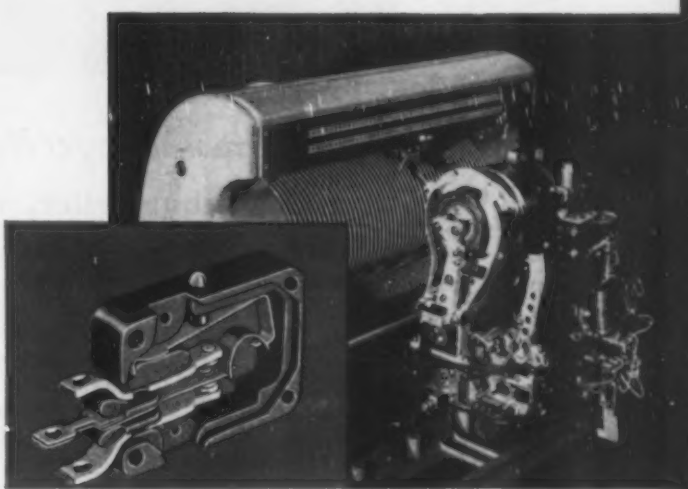
Seeburg also uses Acro switches on Government military applications.

Acro switch performance has helped Seeburg record players gain an enviable reputation in the trade for dependable, money making performance.

This same precision switch performance can be put to work for you with profit. Write for catalog listing over 7,000 standard Acro Switch and Mu Switch specifications. Our engineering staff will gladly work with you on special applications.



Circular arrangement of six single pole single throw Acro open blade snap switches on Seeburg "Credit Cancel" unit.



A single Acro Model M switch controls the actuating mechanism of the record selector.

ACRO MANUFACTURING COMPANY

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Representatives In Principal Cities

"THE BIGGEST LINE OF LITTLE SWITCHES"

HIGH VOLTAGE D.C. SWITCHES PUSH BUTTON PANEL MOUNTS MIDGET SWITCH

Put this magic ingredient into your products to make them *better, safer, lighter, stronger!*

The same reasons why your wife invests in today's new curtains and draperies made from glass fibers are equally important to you, as a businessman.

For this wonder material, with all of its remarkable properties, is being manufactured to a high degree of quality for use in hundreds of products by one of the glass industry's pioneers—Pittsburgh Plate Glass Company.

If you use rubber, plastics or any variation of these materials—tapes or cordage—fabrics—insulation to contain heat or cold—or countless other materials, you'll find that Pittsburgh Fiber Glass Yarns or Superfine insulation will add new features to your product's efficiency and function.

Accept our invitation for a no-cost inspection and test of Pittsburgh Fiber Glass for your product. Simply write our executive or district offices for arrangements. Pittsburgh Plate Glass Company, Fiber Glass Division, 420 Fort Duquesne Boulevard, Pittsburgh 22, Pa. District Sales Offices: Chicago, Cincinnati, Cleveland, Detroit, New York and Washington, D.C.

Pittsburgh Fiber Glass Yarns are packaged for all textile machinery and made in standard 150's, 225's, 450's and 900's, twisted and plied for any wanted build-up.

Pittsburgh Superfine Insulation is made in a range of densities, grades, thicknesses and blanket roll sizes, with a variety of binders and facings available.

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EEMCo technical bulletin

new motor for small fans, blowers, pumps

light ★ 23½ ounces

small ★ 6 inches long, 2¼ inches in diameter

rugged ★ 2000 hours brush life, minimum

actual size

This new EEMCO motor was designed for a wide variety of uses where a light, compact unit with unusually long life is required. It is tooled for large quantity, low cost production. All cast components are either die, investment, or molded.

The basic design is extremely flexible. Speed can be varied by changes in winding and/or lamination stack length. Wound for 28 volt D.C.; it can be wound for either 110 volt A.C. or D.C.

performance data

- ★ 50 watts continuous at 7500 RPM
- ★ 40° centigrade rise at sea level operation and normal ambient
- ★ Weight 23½ ounces
- ★ Dimensions 6 inches long, 2¼ inches diameter
- ★ Brush life at least 2000 hours
- ★ Designed to meet ANM-40 specifications

electrical engineering and manufacturing corporation
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3-520

All over the World

FROM T.V. TO MIL-T

Companies to whom Wheeler has supplied wound coil components are well established in world markets . . . Sperry, Bendix, AC Spark Plug, I.B.M., Delco, R.C.A., Westinghouse, Stromberg Carlson, G-E and many more. Hence, we can find great satisfaction in the knowledge that wherever equipment "Built in USA" by these famous companies and others may be in use, the hidden values of fine quality Wheeler components are contributing to goodwill and excellent service.

We welcome inquiries for standard or special types of wound coil components . . . transformers, chokes, reactors, inductors . . . including MIL-T, hermetically sealed and FOSTERITED* units . . . in large or small production runs . . . produced under single control from wire drawing to final electrical test.

*The WESTINGHOUSE encapsulating insulation that gives a high degree of protection to small transformers. Applied by Wheeler under license.

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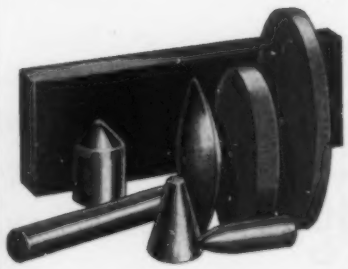

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Wheels, Points, Blocks, Sticks, Cones

—are ideal for manual or machine application—require no special equipment—always ready for instant use. For over 30 years, Cratex has served industry with unparalleled results — an unduplicated reputation for lowering "unit costs" in burring, smoothing and polishing operations. Investigate Cratex Rubberized Abrasives . . . "The World's Finest For Industrial Use" . . . send today for Descriptive Catalog which gives full details, applications and prices.

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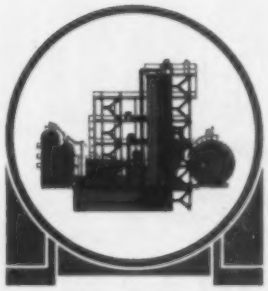

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for every industry

When you need electric motors . . . in any rating, or frame type . . . one or a thousand . . . *always* look for the Fairbanks-Morse Seal. For over 120 years it has stood for the finest in manufacturing integrity to *all* industry.

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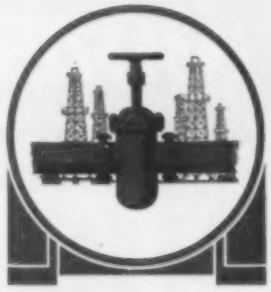

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Fairbanks-Morse explosion-proof motors for all installations where fire hazards exist.

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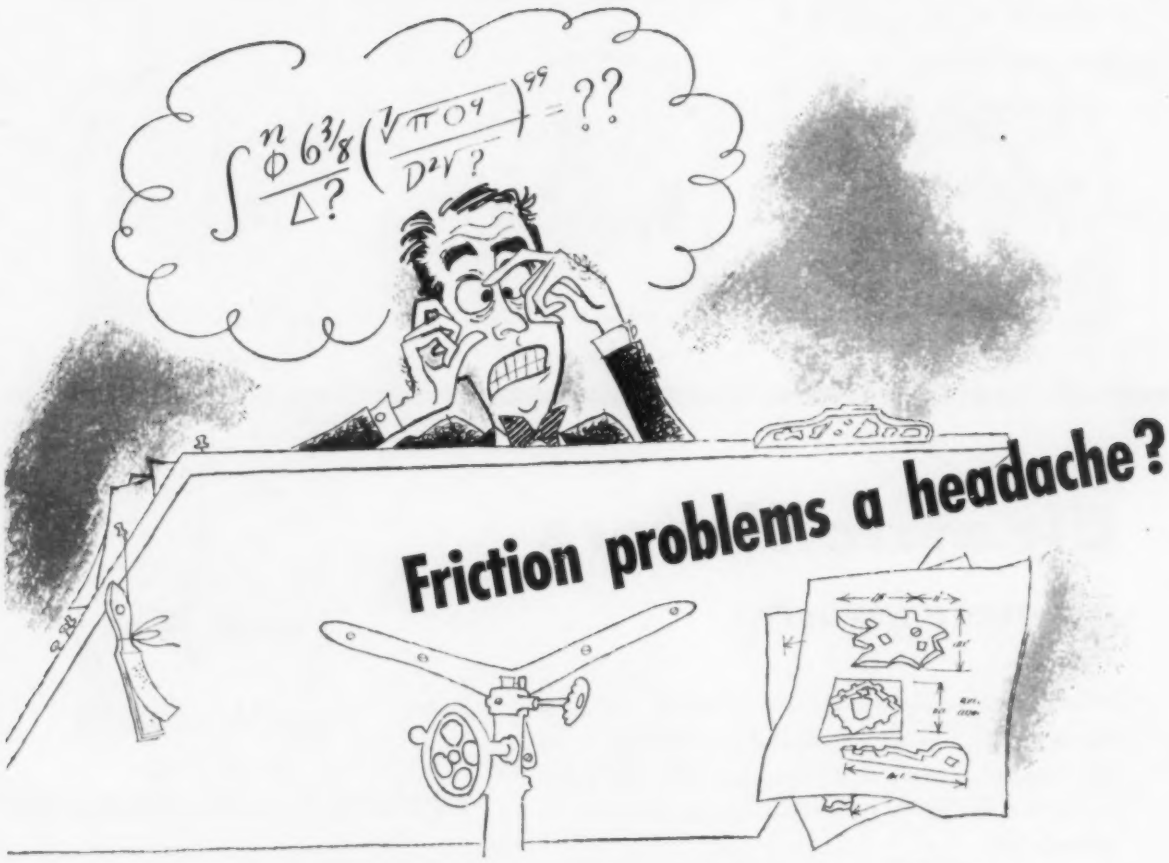

Friction problems a headache?

Let your J-M Friction Specialist help find a cure

If your organization is having friction material problems, a phone call or letter from you will enlist the help of a Johns-Manville specialist.

His expert knowledge and wide practical experience will help you quickly select the right friction materials you need, no matter what the job.

How can Johns-Manville give you this "Johnny-on-the-spot" service? Three short sentences tell the story:

1. **We are pioneers** in the manufacture of friction materials for every type of equipment.
2. **We have built** up a storehouse of "know-how" by our contacts in supplying these materials to practically every type of industry.
3. **We maintain** one of the most extensively equipped laboratories in the world for the development of friction materials.

So regardless of your problem, don't lose time. Instead, phone or write your nearest Johns-Manville office—or Johns-Manville, Box 290, New York 16, N. Y.—and a J-M friction specialist will be on his way to help solve it in a hurry.

Here's your guide to the right friction material for the job—

Even if you do not have an immediate friction material problem you may have use for a reference source. Booklet FM-12A (right) is yours for the asking. It contains complete descriptions, specifications, and a handy selector chart. For your copy write Johns-Manville, Box 60, New York 16, N. Y.

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Johns-Manville *Asbestos* FRICTION MATERIALS

*REO DESIGN ENGINEERS SAID...

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WE'LL SPECIFY

STRESSPROOF®

SEVERELY COLD-WORKED, FURNACE-TREATED STEEL BARS

AGAIN!

Reo Motors, Lansing, Mich., have again specified STRESSPROOF —this time for the power shaft on their new rotary lawn mower.

Another Reo Lawn Mower to Use STRESSPROOF

Reo engineers needed *top performance* from this new drive shaft . . . so they insisted on STRESSPROOF! They knew from years of successful experience with STRESSPROOF that it could take abuse. It had both the strength and wearability to stand up under the toughest service—and its excellent machinability was most welcome from a cost standpoint.

The alternative to STRESSPROOF would have been a heat-treated part, with the attendant cleaning, straightening, and machining problems.

Only STRESSPROOF gives you a unique combination of four qualities *in-the-bar:* Strength, Wearability, Machinability, and Minimum Warpage. Yet it costs less than the other quality cold-finished steel bars.

STRESSPROOF makes a better part at lower cost! It is available in cold-drawn or ground and polished finish.

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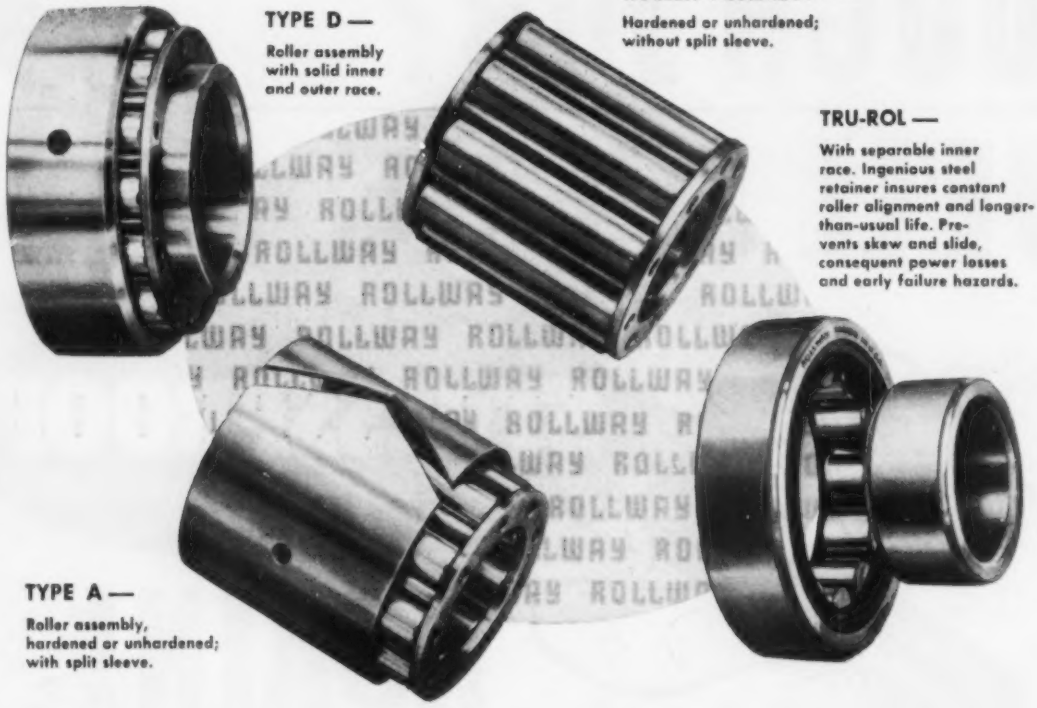
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Roller assembly with solid inner and outer race.
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Hardened or unhardened; without split sleeve.
TRU-ROL —
With separable inner race. Ingenious steel retainer insures constant roller alignment and longer-than-usual life. Prevents skew and slide, consequent power losses and early failure hazards.
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Lower First Cost Equal to plain bearings in *overall* cost—lower than most other roller bearings in *initial* cost—Rollway Steel Cage Bearings step up the operating efficiency of your machines . . . while keeping them competitively priced.

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Consider These 6 Advantages of Designing Your Product With a . . .

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTOR**

Perhaps you will find the answer to your problem, *"How can we give our product more sales appeal?"* by redesigning with the help of the Lamb Electric engineering department.

A Lamb Electric Motor — especially engineered for your product — makes available the following six important advantages:

IN THE MOTOR . . .

1. Reduced cost, weight, space.
2. Exact mechanical and electrical requirements.
3. Thorough dependability.

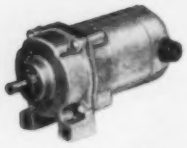
IN THE PRODUCT . . .

4. Better performance.
5. Improved appearance.
6. Compactness, less weight.

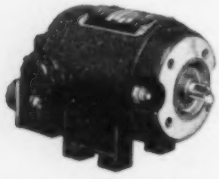
Our engineering department will be glad to team up with yours to help obtain these results.

The Lamb Electric Company • Kent, Ohio

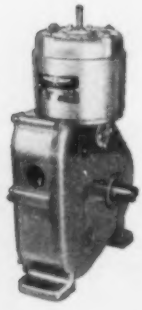
In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario



Pocket-size gear motor for machine applications requiring low output shaft speeds with relatively high torque.



Compactly designed motor developed for metering pump and special instrument service.



Gear unit for reversing service with constant speed capacitator type motor.

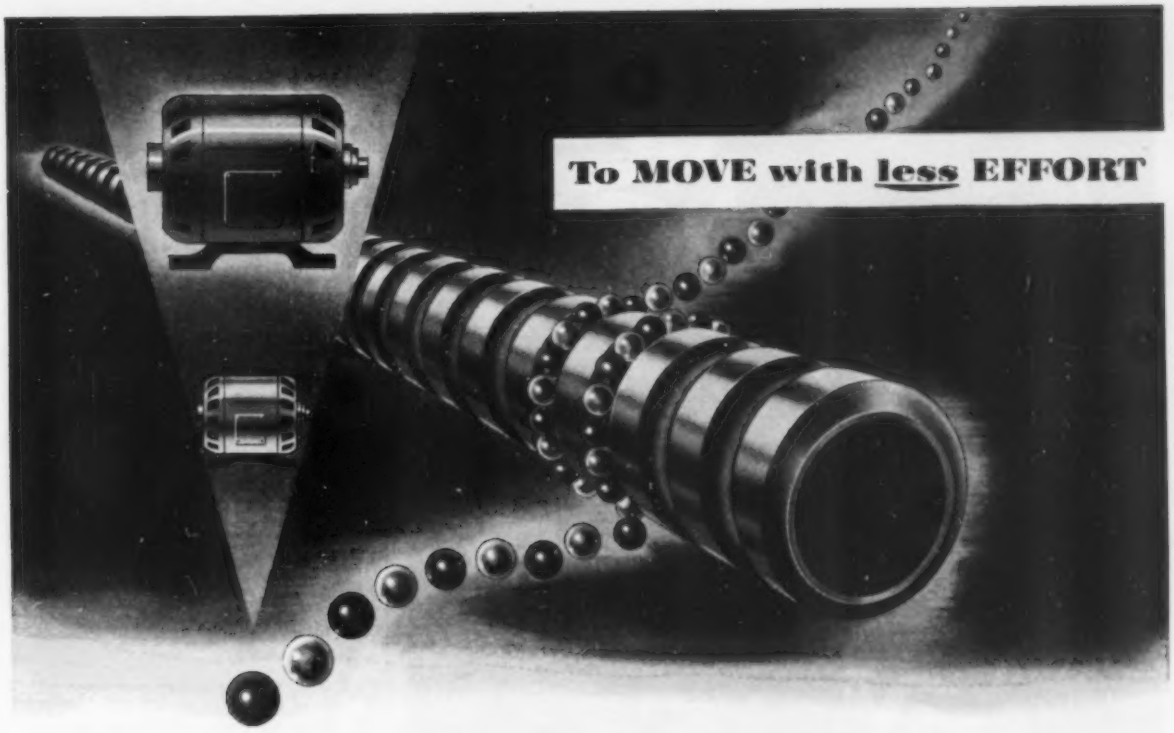
Planetary inbuilt speed reducer permits a straight-line drive, symmetrical construction; insures good performance.

Compactly designed turbine provides dependable operation for canister-type vacuum cleaner.

THEY'RE POWERING AMERICA'S *Finest* PRODUCTS

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**



WE'VE DISCOVERED HOW TO

Shrink your motors

-by Floating a screw on a stream of balls!

We eliminate the need for the excess power that was added to overcome friction in the old-fashioned screw-type drives.

Ball-screw actuators made by Cleveland Pneumatic have an efficiency as high as 90% on most types of drives for machines. This lets you use a ½-horsepower motor instead of a 1-horse... a 5-horse instead of a 10... with power to spare.

It's done by replacing the famous old high-friction Acme thread principle with a spiral ball-bearing thread that does wonders for efficiency. Sliding friction is replaced by the rolling action of the screw and nut over the steel balls in the threads.

These "AEROL" Ball-Screw Actuators are at work *now*... in the air at scores of spots on aircraft; on the ground in machine tools, in research equipment, on trucks and cars; at secret locations on difficult defense projects.

We can also cut down friction in *your* designs and products... by shrinking the size of motors, easing the effort it takes to hand-actuate a device, making equipment move faster yet come to a more precise stopping point under any condition. Our Actuators operate smoothly under the greatest extremes of heat and cold.

When can we discuss with you the application of our AEROL Ball-Screw Actuators in your business? If you wish to know more about Cleveland Pneumatic Actuators and their uses... write for our booklet.

Cleveland Pneumatic
Tool Company CLEVELAND 5, OHIO

Department E-11

BALL-SCREW ACTUATORS • AUTOMOTIVE SHOP EQUIPMENT
AIR-OIL IMPACT ABSORBERS

World's Largest Manufacturer of Aircraft Landing Gears

To CUSHION SHOCK

CPT's shock absorber principle combines pneumatic and hydraulic cushioning. It can control minute vibrations or tons of impact. It is the shock absorber for the largest aircraft landing gears (CPT is the world's biggest manufacturer of landing gears), and the same principles are often adapted to finger-sized units. May we discuss with you how to take the shock out of stopping or the motion out of vibration?

Temp-R-TAPE

A pressure-sensitive tape meeting Class H insulation requirements.

Temp-R-Tapes combine the excellent temperature stability, the resistance to ozone, oxidation, and weathering, and the high electrical characteristics of the silicones with the simple, dependable form of the pressure-sensitive tapes.

Temp-R-Tape can be applied at temperatures as low as —65°F. and retains its adhesion at temperatures up to 400°F.
Temp-R-Tape is unique as:

- *a Class H insulating tape*
- *a high temperature sealing tape for heating ducts*
- *a wrapping tape for any material to be subjected to temperature extremes*
- *a masking tape for high and low temperature use*

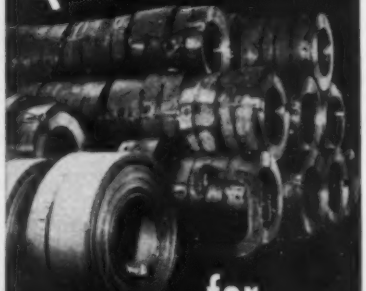
WRITE FOR SAMPLES AND LITERATURE

First in silicone rubber fabrication

COHRLASTIC
408 EAST ST. • NEW HAVEN, CONN.

PRODUCT OF THE
Connecticut
HARD RUBBER COMPANY

Quick Relief for SLITTING SERVICE Headaches



● If your monthly requirements of coiled strip exceed 100 tons, in many different widths and gauges, installing a Yoder slitter will not only result in worthwhile economies but in eliminating costly production bottlenecks.

Coiled strip in standard widths is obviously lower in first cost than slit-to-width strip; the sources of supply are more numerous and deliveries much quicker.

The savings effected by doing your own slitting of moderate tonnages, soon pays for your investment in a Yoder slitter. Equally important, your inventory requirements and production planning are greatly simplified, as you can, from a relatively small stock of standard widths, in a few hours supply your own needs in slit strands.

The economies as well as the mechanics of slitter operation are fully discussed and illustrated in the Yoder Slitter Book, free on request.

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5522 Walworth Ave., Cleveland 2, Ohio

Two World-Famous
Organizations Become One — *and*

this is what happens...

Just a few years ago, National Pneumatic, the world's leading producer of transit and railroad safety equipment, and Holtzer-Cabot, a pioneer and leader in the electrical field, became one organization.

Manufacturing was consolidated at the big Boston plant of Holtzer-Cabot. Progress was swift and sure in both companies' ability to serve customers even better.

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All the familiar products, plus many new ones are now being made under a new high efficiency. Design and Research Departments have grown on a full scale to match the increased activities of these two great companies — with some left over!

To industry this is a new, large and dependable resource. Research, development and manufacturing facilities are available for mechanical, pneumatic, hydraulic, electric and electronic products either singularly or combined. Inquiries on present products or development work are welcomed.

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AND
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WATERMAN PRODUCTS for POSITIVE CONTROL

Here are four Waterman Products designed to fit your needs. If you desire a completely new design our experienced engineers are available to serve you.

SOLENOID VALVES for operation to 3000 psi. Designed for remote control non-corrosive fluids. Poppet construction eliminates leakage. Impregnated coils are oil and moisture resistant. Available in 110-220 A.C.

UNLOADING VALVES for pressures to 3000 psi. Flow rates to 30 G.P.M. Fast acting, easily adjustable, maintain desired pressure settings without continuous readjustment. Hardened poppets eliminate leakage. Large passages insure minimum pressure loss.

ADJUSTABLE FLOW REGULATORS for cylinder speed control over 50% range for pressure to 3000 psi. Ideal for cylinder speed adjustment yet maintains constant speed for Machine Tools—Farm Equipment—Packaging Machinery—Steel Mills etc.

CHECK VALVES
one piece construction Nylon Poppet, light weight aluminum body. Low pressure drop.

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ENGINEERING COMPANY
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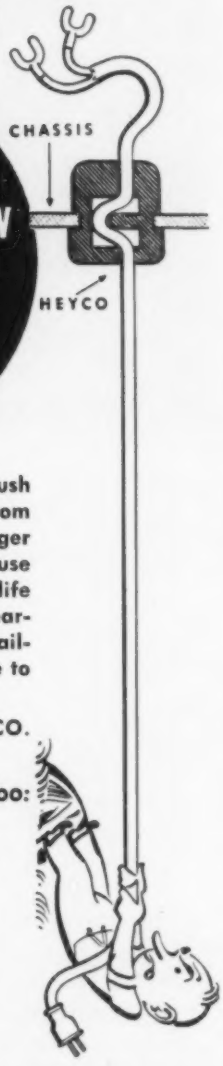
Send for these Engineering Data Dept. E

HEYCO Nylon Strain Relief Bushings cut production costs and improve product quality!

Facts you should know about HEYCO Strain Reliefs



Heycos absorb all cord pull, push and torque and insulate wire from housing. With Heycos it's no longer necessary to tie wire knots or use insulating grommets. Product life is increased and product appearance is greatly improved. Available in all sizes from clock wire to S-10/3 cable.

HEYMAN MANUFACTURING CO.
KENILWORTH 3, NEW JERSEY

It's easy to apply Heycos, too:

1. *Slip over wire*
2. *Snap into hole*

FULLY APPROVED BY
Underwriters' Laboratories and Canadian Standards Asso.

HEYCOS positively eliminate strain on terminals!

Send for Samples and Specifications

HEYCO

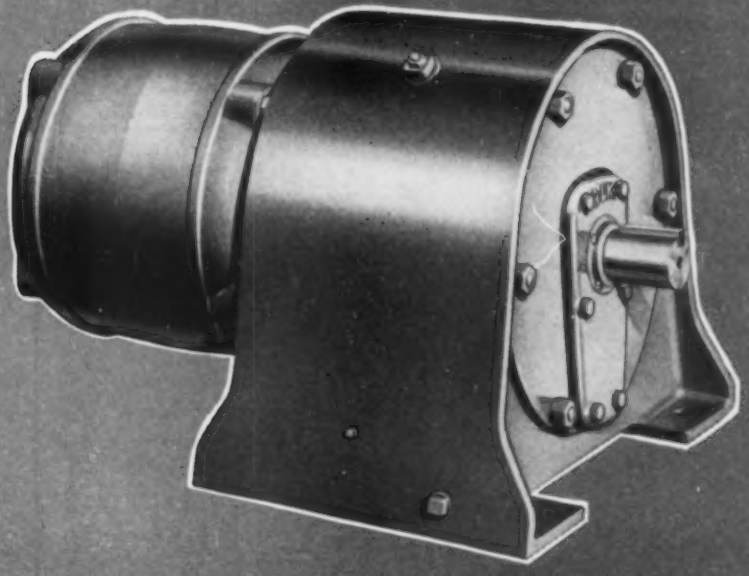
For Double Protection Use Approved HEYCO Strain Relief Bushings

Announcing the *-Newly Designed-* Integral

ALL-STEEL FALK Motoreducer

(Gearmotor Type–Supplementing Falk All-Motor Line)

. . . with completely standard round-frame, D-flange motor



Check and Compare these features...

Meet a faithful old friend in a new, modern dress! The famous, time-proved Integral Type *all-steel* FALK Motoreducer (Supplementing Falk All-Motor Line) has been redesigned into a compact, streamlined unit providing the utmost in space economy—but retaining all the application versatility, long-life performance, easy-maintenance features and superior structural qualities that have made Falk Motoreducers the recognized standard throughout industry.

In this new Integral unit—rated in accordance with AGMA Standards—a *completely standard* round-frame, D flange NEMA motor is mounted directly on the all-steel Motoreducer housing. The motor remains a separate piece of equipment. Size and arrangement of the standard housing permit widest ratio range—from 3.36:1 to 542:1.

In order to meet the widely diversified needs of those who manufacture industrial equipment, the newly designed Integral Motoreducers are available in horizontal and vertical models, both in concentric and right-angle types; double, triple and quadruple reduction; horsepower range, 1 to 40 HP. Prompt stock shipment in standard ratios is offered. Write for Bulletin 3104.

Every FALK Motoreducer has these "In-built" Factors—

Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

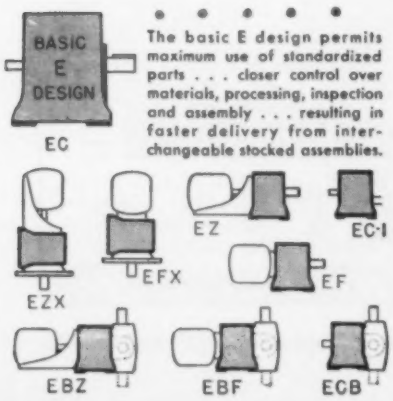
All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.

Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.

Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

Sealed Housings. Dual closures and one-way vents keep oil in, dust and moisture out. Units are splash-proof, leakproof, dustproof.



The basic E design permits maximum use of standardized parts . . . closer control over materials, processing, inspection and assembly . . . resulting in faster delivery from interchangeable stocked assemblies.

FALK ...a good name in industry

THE FALK CORPORATION . 3001 W. Canal St. . Milwaukee 8, Wis.

WRITE FOR BULLETIN 3104

THEY ARE WORTH MUCH MORE

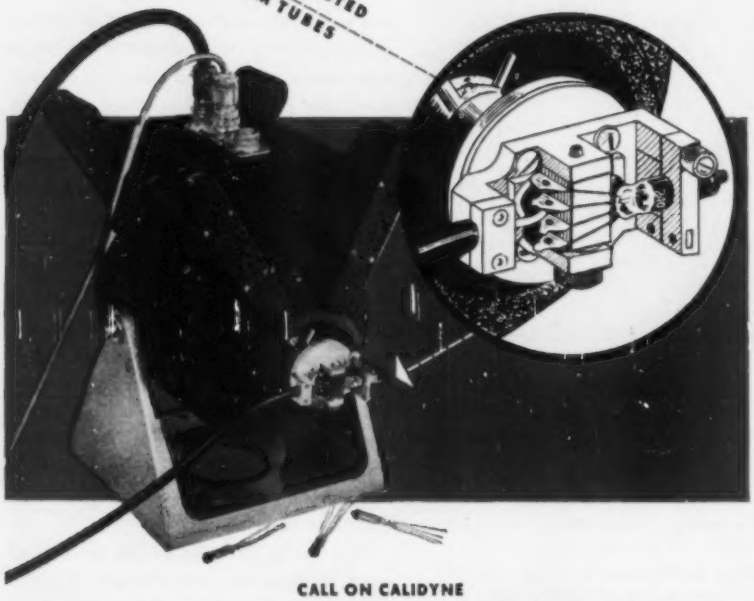
VIBRATION-TESTED VACUUM TUBES

CALIDYNE DOES

From time to time vacuum tube manufacturers and users have asked us if we make a standard shaker system or could build one for vibration testing vacuum tubes. The answer is that we do make one and can build others to suit your particular requirements. The value of such a system is obvious from both sales and use points of view.

VIBRATION IS OUR BUSINESS

Calidyne's business is to build shaker systems to meet individual needs. Wide frequency ranges are available. We build shakers to do frequency cycled tests varying from 10 to 1000 cycles per second. These give actual physical vibration in a linear plane. Acceleration levels go up to 15 g's on table loads of about 2 pounds. It is possible to develop a shaker that operates at frequencies up to 10,000 C.P.S.



CALL ON CALIDYNE

If you make or use vacuum tubes for computers, guided missiles, radar, sonar or mobile applications, you must recognize the importance of dependable tubes proved by pretesting. Outline your problem in detail and let us see what we can do with it. You may then be able to *pretest* your vacuum tubes for vibration *before* putting them in the field.

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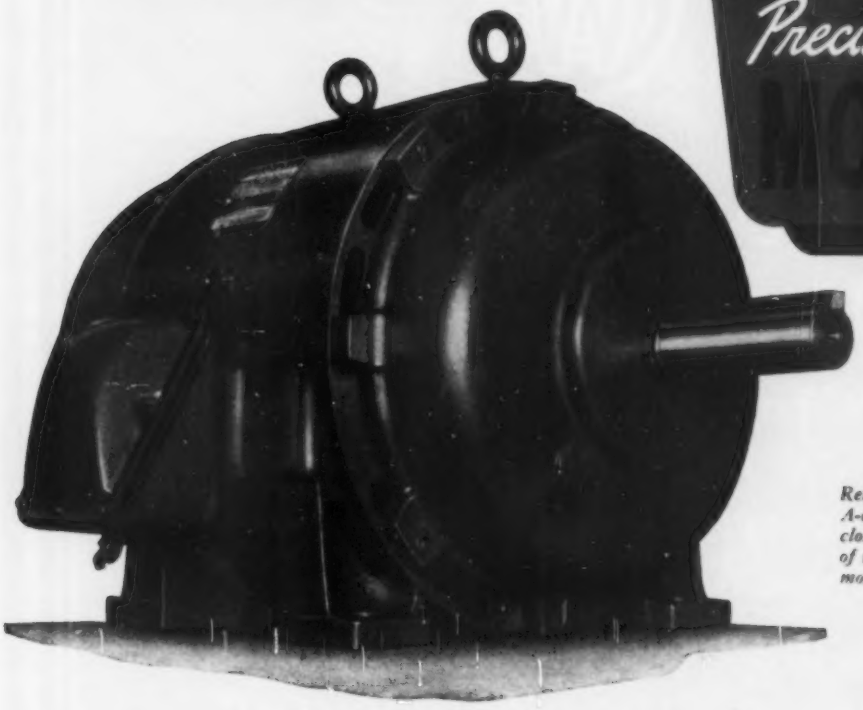

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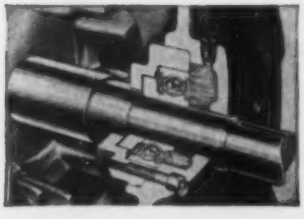

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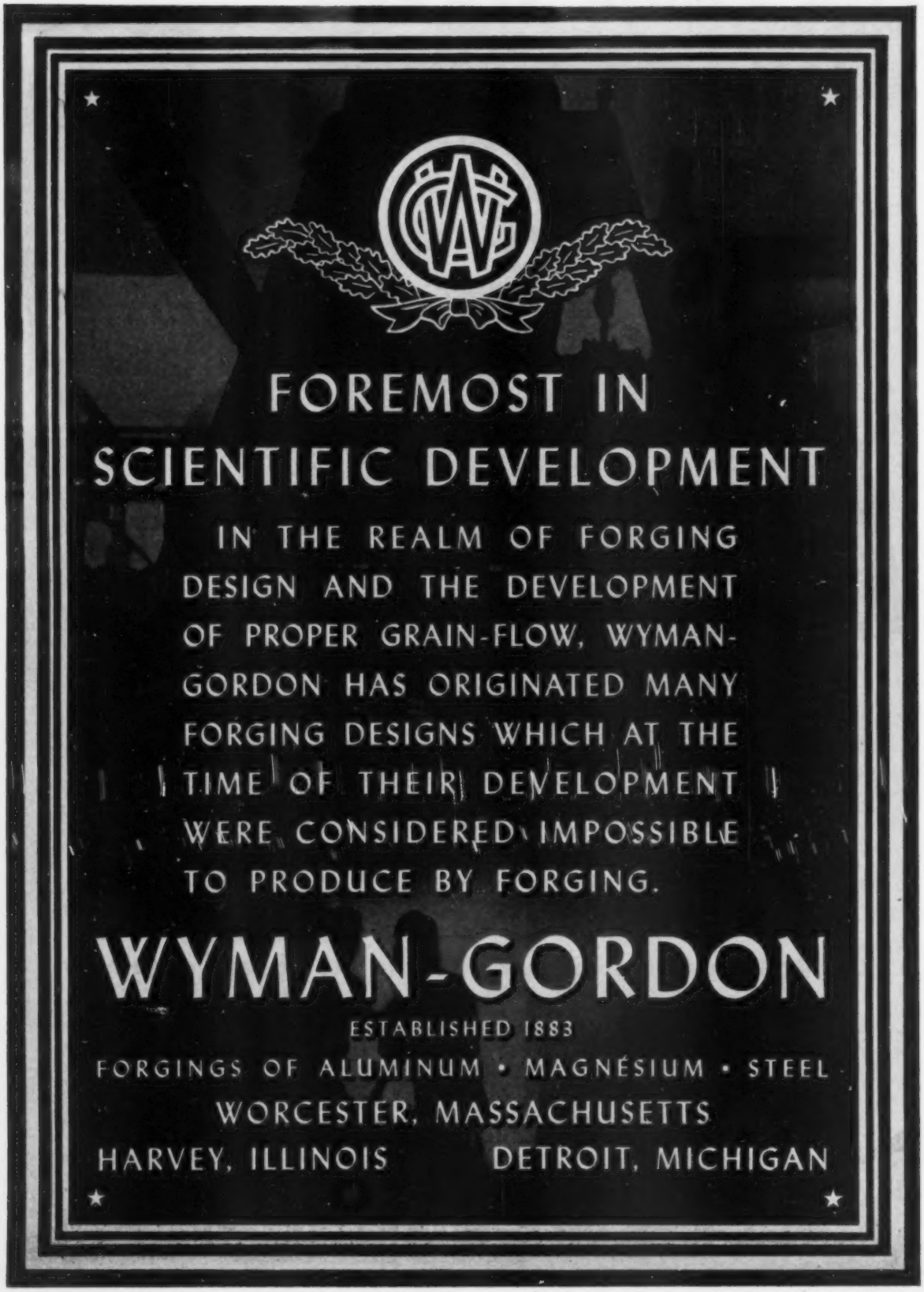
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how Cindus X-Crepe® helps micarta® "take the bends" in plastic sink tops

Today, MICARTA, manufactured by Westinghouse Electric Corporation, is fabricated into thousands of sink tops—*without* seams, cracks or metal strips. Because of all-directional-stretch X-CREPE, the decorative plastic MICARTA is a *single, continuous surface—from the top of the splash board to the front edge.*

Before X-CREPE, decorative plastics—table and sink tops, furniture veneers—were limited to flat surfaces. Forming interior arcs and rounded edges was impossible. Non-stretchable paper core-stock, used as a saturating base, cracked or split when efforts were made to form it. Corners were made by joining two separate pieces in hard-to-clean, food gathering coves.

Sheets of stretchable CINDUS X-CREPE, saturated with phenolic resin, are pressed, under heat, into a single flat sheet, ready for subsequent forming. Now, X-CREPE's all-directional stretch really comes into play. The flat sheet is reheated and formed—bent into the shapes desired—without cracking or breaking.

In a simple or compound curve, X-CREPE's formability gives top performance at lowest cost.

This example is typical of hundreds of cases where manufacturers have standardized on X-CREPE because it fills a wide variety of needs better and more economically than less versatile materials. We can tailor X-CREPE to fit *your* needs.

Write today for your FREE CINDUS Design Engineer's Portfolio containing samples and complete information.

X-CREPE® is stretchable, pliable, formable. It can be impregnated, coated, laminated—or combined with cloth and fibers, films and foils to extend the use of such materials far beyond their usual limits. It can be used like cloth . . . instead of rubber . . . in place of cork . . . and for jobs where no other material will do— Available in a wide range of basis weights — sheets, rolls, die-cut shapes, bags and liners.

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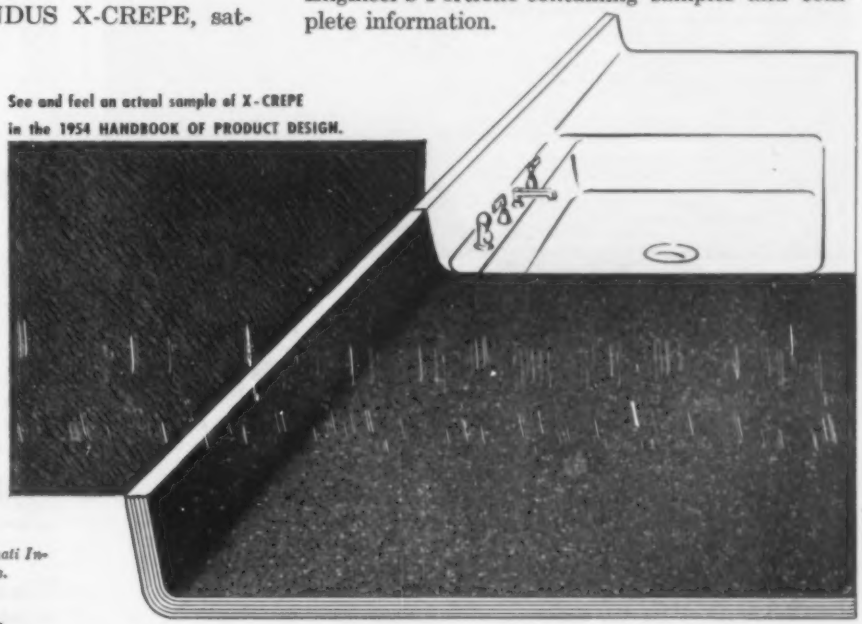

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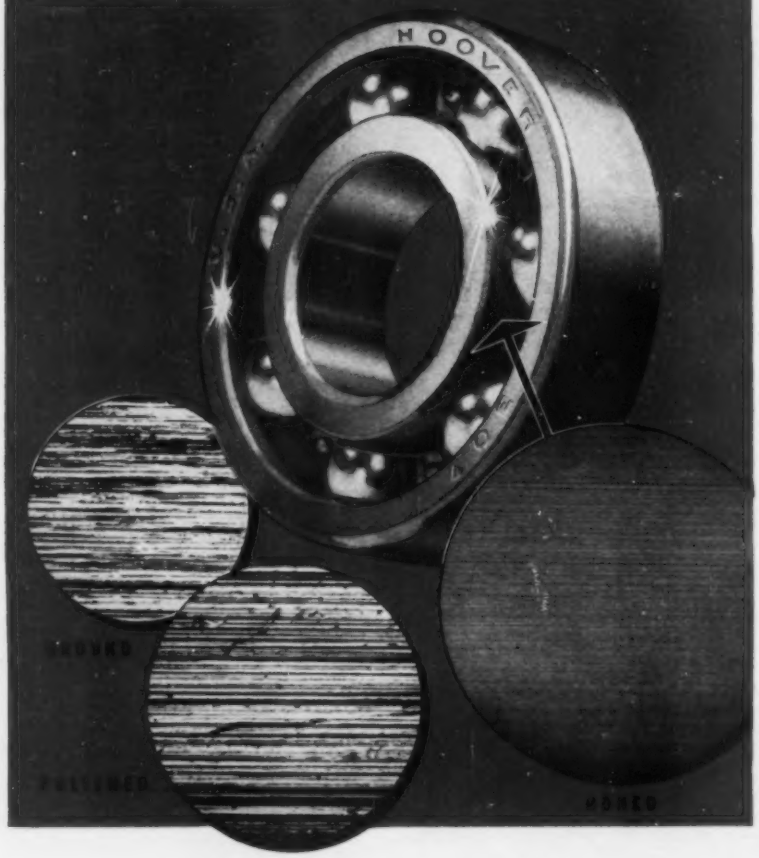

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HOOVER BALL BEARINGS

The photographs reproduced above are magnified one hundred times so you can see the difference between ground, polished and honed raceways. The process and the special machines for the honing operation are exclusive, patented, Hoover developments. Honing by Hoover goes far beyond grinding and polishing to achieve a surface that assures amazing quietness plus *longer bearing life . . . and greater load capacity.* That's why Hoover Ball Bearings are the choice of distinguished American manufacturers of fine machines and equipment.

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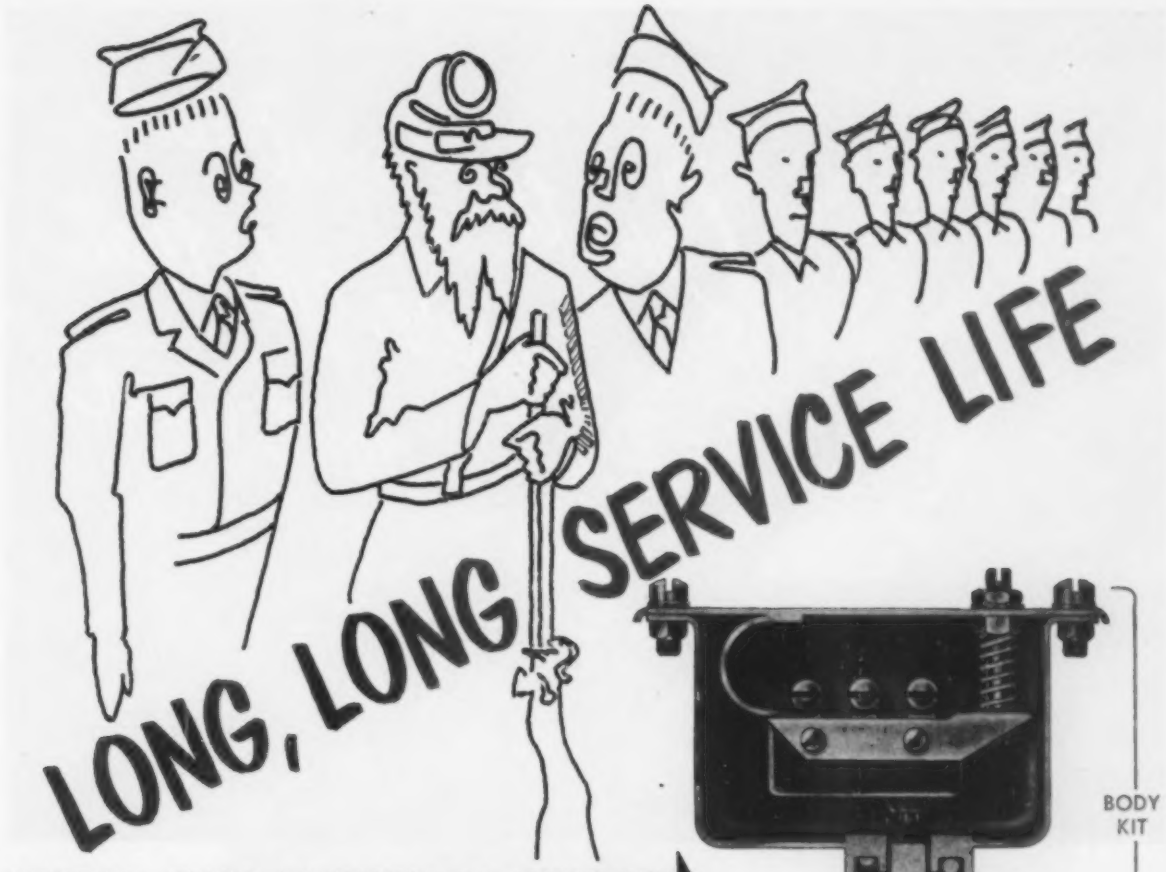
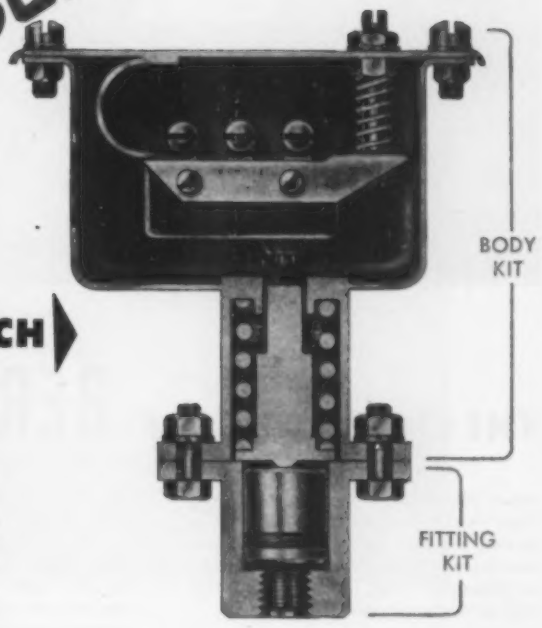


MODEL 9612 PRESSURE SWITCH



Belongs where millions of cycles are expected, on production equipment, where service troubles are taboo. The original equipment manufacturer can design this component into his product and profit by these additional advantages: Extreme flexibility—the same body kit converts to an infinite number of service conditions by simply changing fitting kits—(see table); High proof pressure even at low settings—protection against surge damage; No unwanted actuation from vibration or harmless line surges; Switch may be mounted in any position—no levelling or balancing required; Mounting bracket adjustable up and down and 360° around the neck of the switch; Tamperproof external setting of adjustable range; All this and more at a lower price than inferior switches due to production savings without sacrifice of quality, a quality standard that has long maintained a high rating for Barksdale and Meletron pressure switches and valves. You are dealing with a national organization, represented in every major industrial trading area by competent field engineers.

Write for bulletin 9612 and the chart on "How to select the correct model Barksdale-Meletron Pressure Actuated Switch for your Application."

PROOF PRESSURE	ADJUSTABLE RANGE	HYD. OIL SERVICE	WATER, AIR, GAS SERVICE
3000 P.S.I.	15 - 200 P.S.I.	-0-H FITTING KIT	-0-WA FITTING KIT
3000 P.S.I.	35 - 400 P.S.I.	-1-H FITTING KIT	-1-WA FITTING KIT
7000 P.S.I.	125 - 1500 P.S.I.	-2-H FITTING KIT	-2-WA FITTING KIT
7000 P.S.I.	250 - 3000 P.S.I.	-3-H FITTING KIT	-3-WA FITTING KIT

BARKSDALE VALVES

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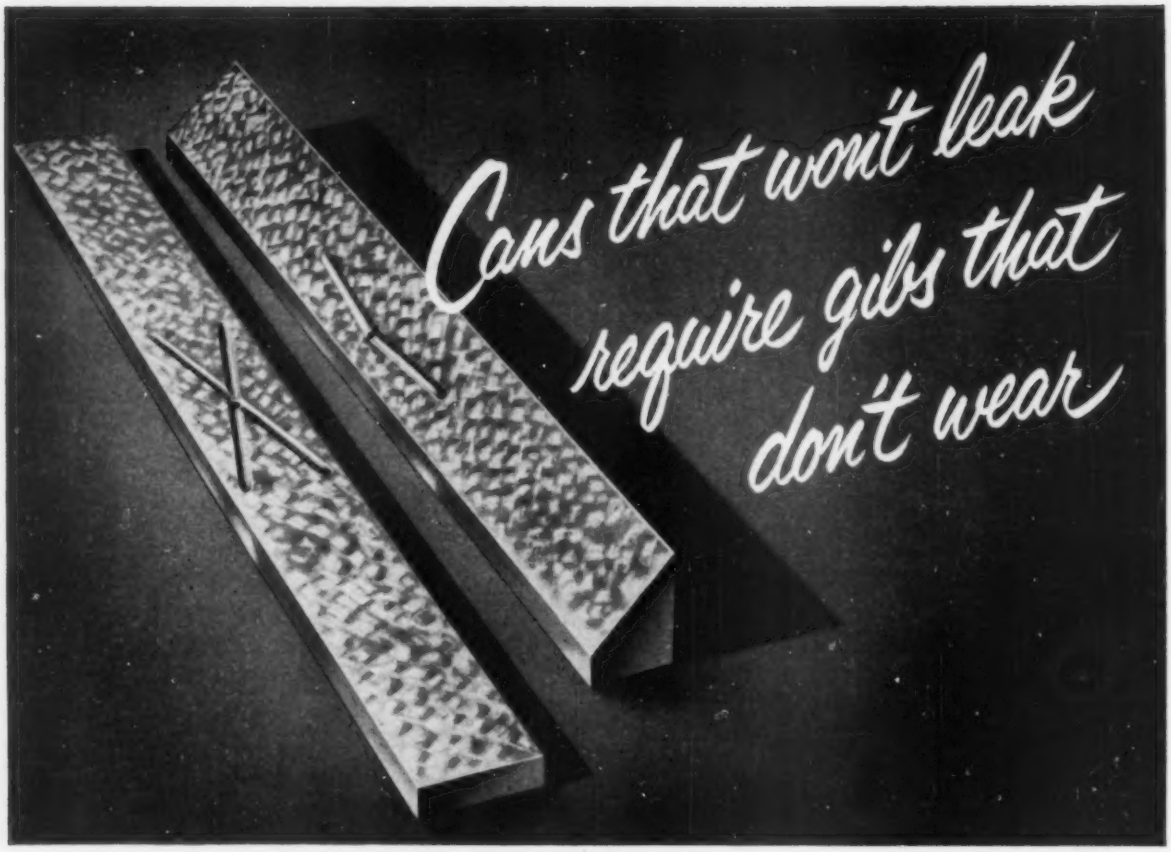

THEY'RE MADE OF BERYLCO BERYLLIUM COPPER

When you discard a tin can, you may not think you're throwing away a precision device, but you are. All parts of a can must be accurately formed to within one ten-thousandth inch, otherwise leakage and spoilage will result.

The flat and bevel gibs shown here are used on a bodymaker producing 12 and 6 oz. spray cans. Twenty-six dies, each guided by similar Berylco gibs, turn out 100 can bodies per minute. Tolerances are so critical that gib wear of less than .001" can cause trouble. Production stoppages pile up headaches, and thousands of cans can be ruined through corrosion.

Gibs machined from Berylco #25 bar stock have now been employed for the "SPRA-TAINER" bodymaker twice as long as any previously used material, and there have been no shutdowns. The superior wear resistance of Berylco is due not so much to its heat-treatable feature—work-hardening alone is sufficient—as to its dense, less porous structure, which reduces friction and makes lubrication less critical.*

Wear resistance is only one of the many desirable engineering qualities of Berylco beryllium copper. Its unique combination of such properties as strength, conductivity, elasticity and fatigue resistance has enabled designers to convert difficult or "impossible" jobs into standard production items.

As the world's largest producers, we will be glad to help you include beryllium copper in your plans for the future. For sample material or engineering assistance, call or write any of the offices below.

VALUABLE ENGINEERING INFORMATION

on Berylco beryllium copper is contained in a series of technical bulletins, published monthly. To receive your copy regularly, write on your business letterhead.

TOMORROW'S PRODUCTS ARE PLANNED TODAY—WITH BERYLCO BERYLLIUM COPPER

** Data supplied by Crown Can Co. (Div. C. C. & S. Co.), Phila., Pa.*

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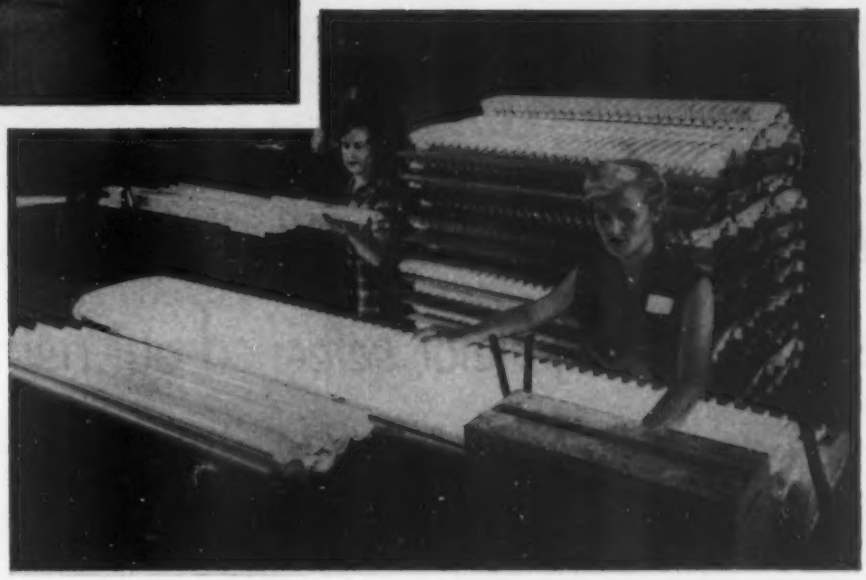
"EVENGLO® polystyrene is our specifications standard in Sylvania lighting fixtures."

says George Clark
Chief Engineer
Fixture Division
Sylvania Electric Products, Inc.



Fixture production line at Sylvania Electric Products, Inc., Wheeling, W. Va.

POLYSTYRENE panels are an important part of a lighting fixture. They must evenly diffuse the light from the fluorescent lamps so that illumination will be high — yet the plastic panels themselves must not be too bright.

Slightest deviation in color or translucence in panels is noticeable—particularly when many fixtures are hung in a single room. Plastic panels therefore must maintain uniform color and translucence. "Evenglo" by Koppers meets this critical requirement for Sylvania, as it has for other manufacturers of quality lighting fixtures.

You get the exact color or translucence you specify when you buy "Evenglo." You get a plastic that is easy to fabricate, and will not warp due to heat from fluorescent lamps.

Let your Koppers application engineer help select the "Evenglo" formulation to meet your specific needs.

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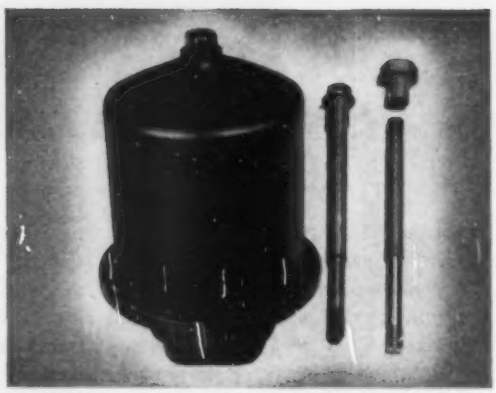
Here's where Purolator screened out rising costs

• Purolator makes oil filters for a prominent auto maker. They're top-notch filters that do a tough job well. Purolator and the car manufacturer are both proud of them.

Not long ago an RB&W "fastener engineer" got loose in the Purolator plant—just when company production executives were looking for a way to lick rising costs. He noticed that the Purolator filter was being assembled with a two-piece fastener made slowly and laboriously on a screw machine.

Our man told the Purolator people about RB&W's batteries of cold-forming machines. Purolator wanted to know more. Now their filter is assembled with a one-piece RB&W fastener that costs far less to make and assemble.

Chances are you can find a stage in your operations where RB&W "fastener engineering" can help you keep costs in line. As a leading manufacturer of all kinds of fasteners, we're always able to recommend and supply the right ones for all your needs. Write RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY, Port Chester, N. Y.



EASIER, FASTER ASSEMBLY undercut high costs when Purolator switched from a two-piece fastener *(right)* to an RB&W-designed cold-formed fastener *(left)* for its famous oil filter.

RB&W

108 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: PORT CHESTER, N. Y., CORAOPOLIS, PA., ROCK FALLS, ILL., LOS ANGELES, CALIF. *Additional sales offices at:* PHILADELPHIA, PITTSBURGH, DETROIT, CHICAGO, DALLAS, SAN FRANCISCO. *Sales agents at:* PORTLAND, SEATTLE. *Distributors from coast to coast.*

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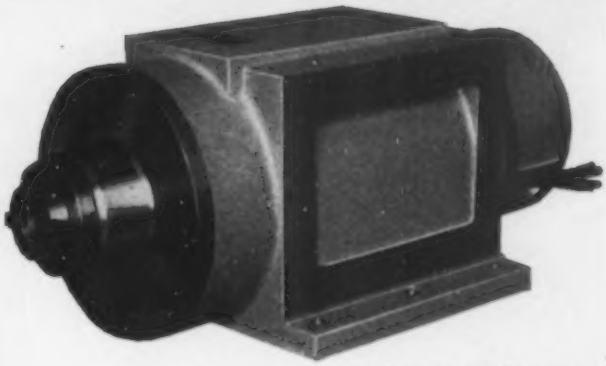
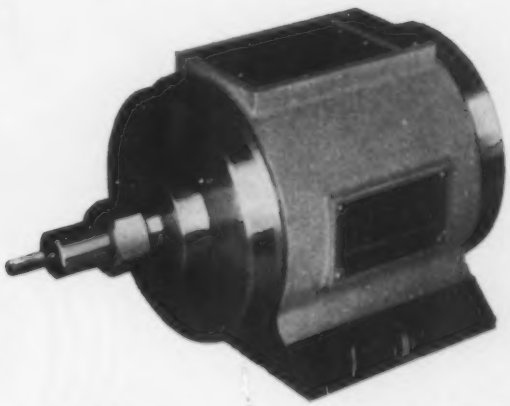
These Heavy Duty, High Speed Milling Spindles can be furnished in a wide variety of horsepowers and speeds, ranging from ½ h.p. to 100 h.p. and from 3600 r.p.m. to 60,000 r.p.m. They are unequalled for long life, trouble-free operation and rugged ability to cut metal fast.



20 h.p. at 7200 r.p.m.
40 h.p. at 14,400 r.p.m.

These Spindles are arranged to operate in horizontal, vertical or angular position, whichever you specify.

15 h.p. at 14,400 r.p.m.



2 pole — 4 pole motor
½ h.p. at 6000 r.p.m.
¾ h.p. at 12000 r.p.m.
1 h.p. at 18000 r.p.m.
1½ h.p. at 36000 r.p.m.

POPE designs and builds *special* High Frequency Spindles for a great range of applications. For recommendations and quotations, let us have your specifications.

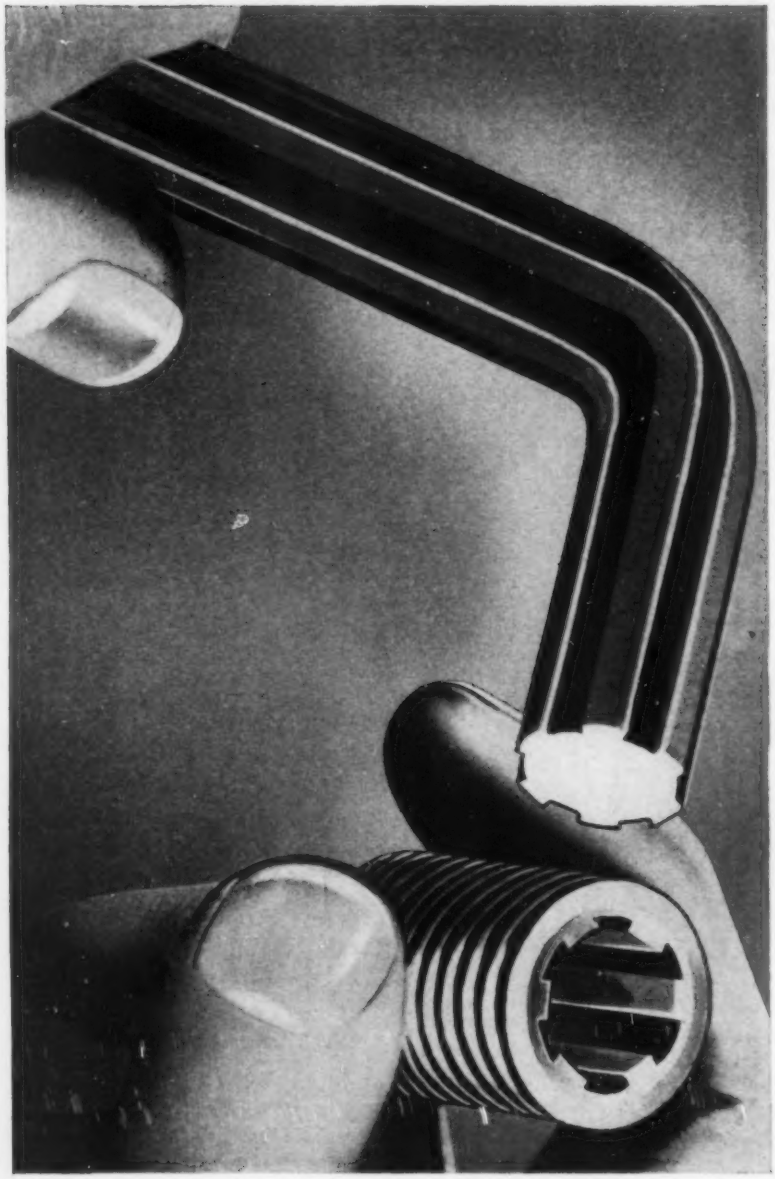
No. 97

Specify POPE PRECISION SPINDLES

POPE MACHINERY CORPORATION

BRISTOL'S MULTIPLE-SPLINE SOCKET SET SCREWS

give far greater HOLDING POWER



The splining principle is recognized by design engineers as the most effective means of transmitting rotary power. That's why it's used in propeller hubs, drive shafts and automobile axles. In Bristol's Multiple-Spline Socket Set Screws, this design results in strength and holding power unequalled by any other screw.

Here are some of the features of Bristol's Multiple-Spline set screws that make them the choice of design, production and maintenance men everywhere . . .

- **greater holding power, permitting use of fewer, smaller screws**
- **easier, faster, and tighter setting**
- **ability to withstand severe shock and vibration**
- **no rounding-out, splitting or breaking under internal wrenching**
- **tamper-proof**

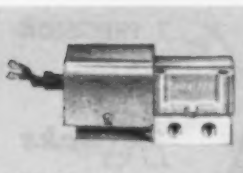
There's no delivery problem with Bristol's Multiple-Spline Socket Set Screws, either. In sizes ranging from No. 2 wire size to ½ inch, all of Bristol's screws are precision-made to conform to Class 3 fit.

Write today for your free copy of Bristol's 40-page catalog on socket screws.

A.3.6

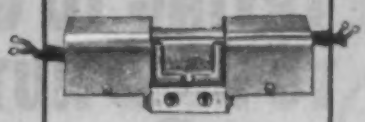
BRISTOL'S SOCKET SCREWS

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.



CC1-25, Solenoid-Operated Spring Return

CC6-25, Foot Operated



CC11-25, Solenoid-Operated Momentary Contact Type

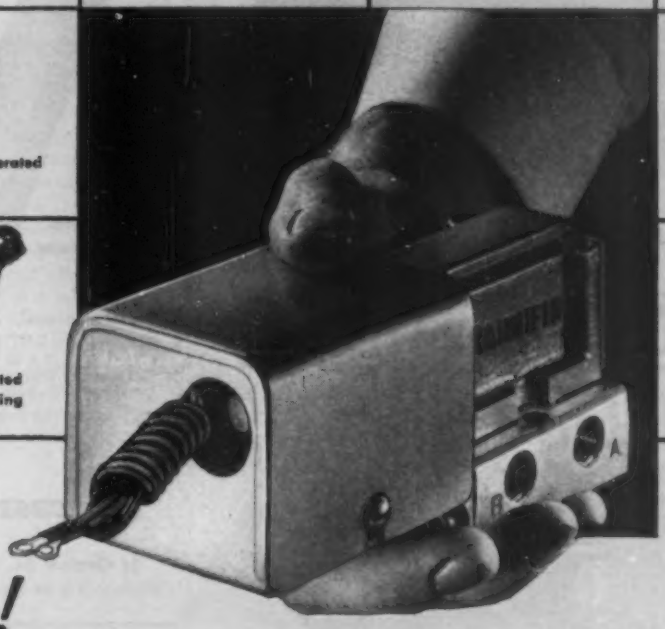
CC7-25, Foot-Operated Locking

CC2-25, Ball Cam-Operated

CC10-25, Piston-Operated Spring Return

CC4-25, Hand-Operated
CC5-25, (Same), Locking

CC12-25, Piston-Operated Momentary Contact Type



Now!

¼" P-M 4-Way Valves!

more compact, less expensive than any similar valves

Here's a new series of direct-operated 4-Way Valves for the control of small, double-acting air cylinders. It's the latest addition to Hannifin's revolutionary "P-M" line.

Designed for easier maintenance. The only moving part is the valve stem with its two poppets. The valve body, which contains this stem, is quickly removed from the separate "manifold" to which all pipe connections are made. Thus, the entire valve can be serviced without breaking line connections.

The CC Series. These new "P-M" 4-Way Valves, nominally of ¼" pipe size, flow so much air that they can be used competitively with other ⅜" valves when ordered with ⅜" ports. They are corrosion resistant throughout and meet J.I.C. recommendations.

Compare! You'll find these new Hannifin 4-Way Valves more compact, simpler and easier to use, and *less expensive* than any comparable valves.

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The new Hannifin Controls Catalog contains complete information and specifications on all Hannifin "P-M" Valves, including this new 4-Way direct-operated series. Write for Bulletin 232.

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IMAGINE TRYING TO GET IN HERE TO HOLD NUTS!

No Problem At All With . . .

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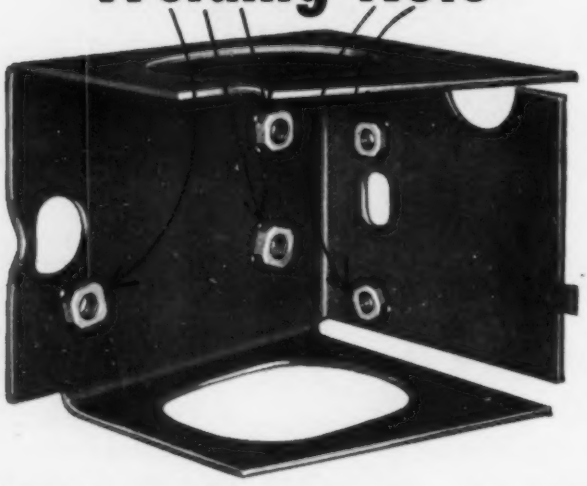
Welding Nuts



With Midland Welding Nuts pre-mounted* in inaccessible places, there is no need to hold the nuts while attaching other parts.

*THIS IS ALL YOU DO — Just insert collar of Midland Welding Nut in hole for bolt or screw, resistance weld the Nut in place, and the Nut is there for the life of the job. Nuts can be fed automatically to the resistance welder.

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This Special Editorial Report provides an informative summary of recent noteworthy developments in ferrous and non-ferrous metals and new ideas in their successful fabrication. It contains invaluable information on new methods of shaping steel . . . new types of metals for high temperature and structural uses . . . new metal-ceramic combinations . . . new stainless and alloy steels . . . new light metal alloys . . . new production techniques. Write to:

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Product Engineering

McGraw-Hill Building,
New York 36, N. Y.

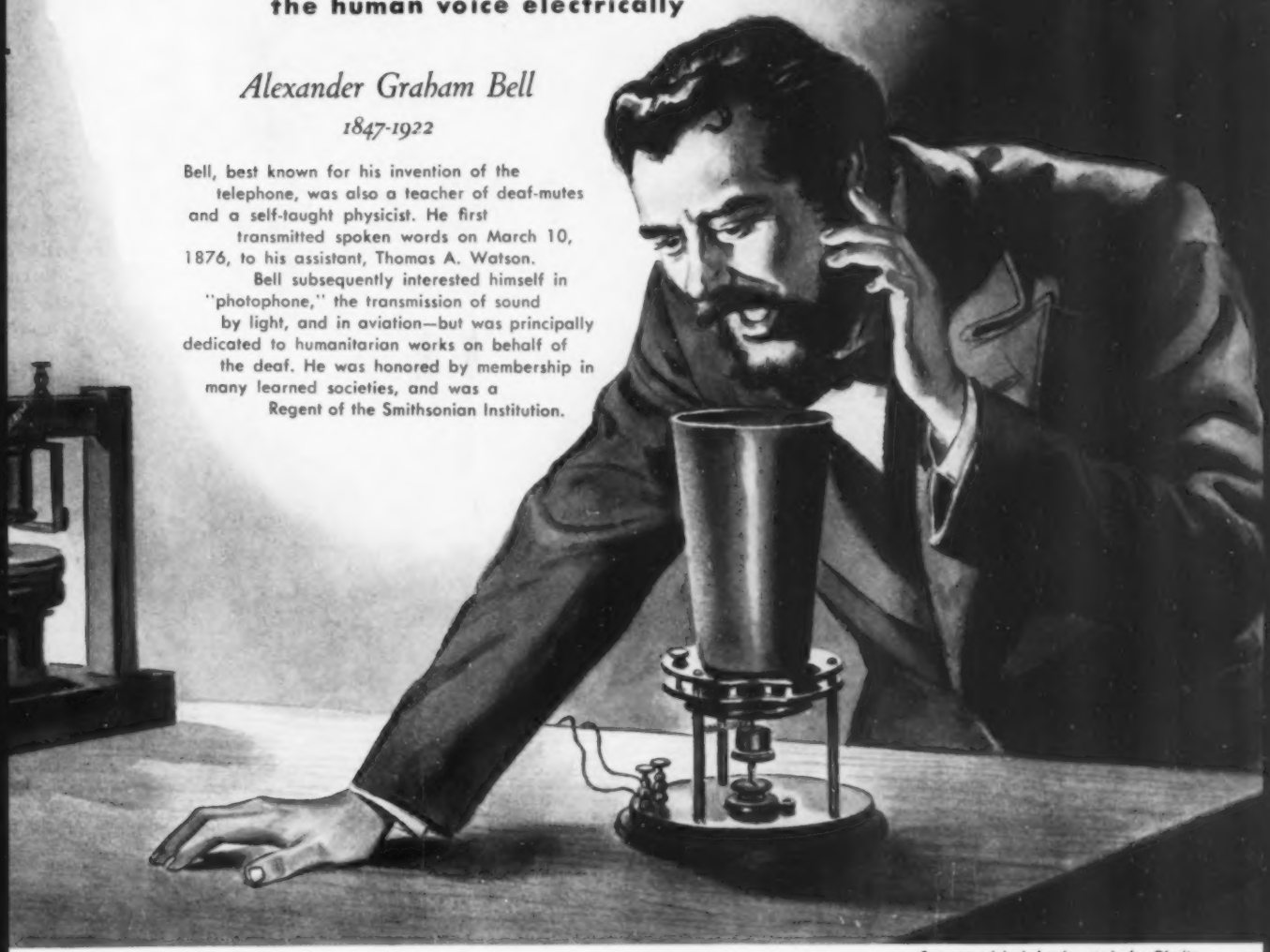
Bell ...First to transmit the human voice electrically

Alexander Graham Bell

1847-1922

Bell, best known for his invention of the telephone, was also a teacher of deaf-mutes and a self-taught physicist. He first transmitted spoken words on March 10, 1876, to his assistant, Thomas A. Watson.

Bell subsequently interested himself in "photophone," the transmission of sound by light, and in aviation—but was principally dedicated to humanitarian works on behalf of the deaf. He was honored by membership in many learned societies, and was a Regent of the Smithsonian Institution.



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FOR *Dependability*

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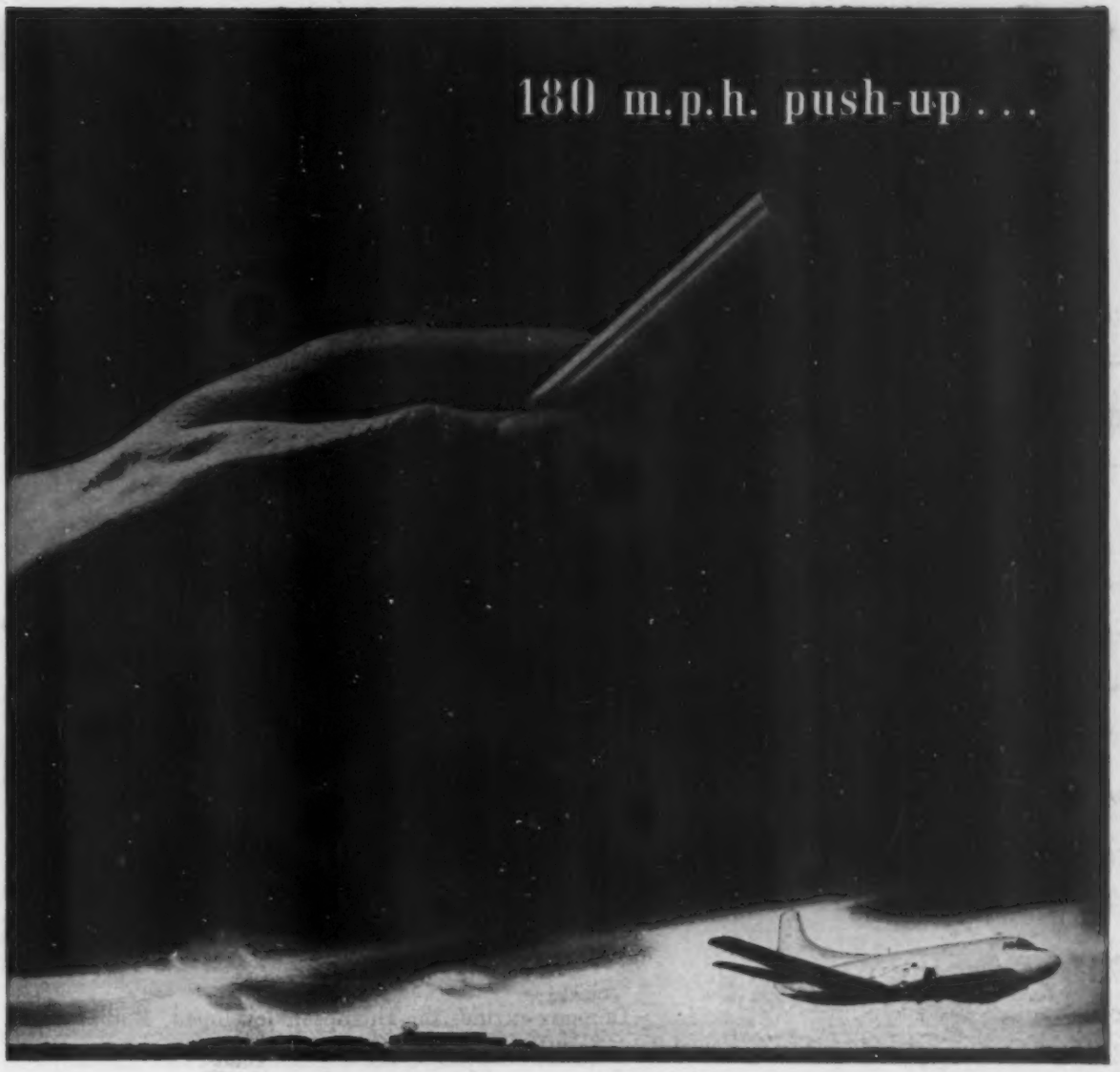
WRITE on company letterhead for Catalog and Engineering Manual No. 40



Any time you fly in a Martin 4-0-4, Superior tubing is probably working for your safety.

Once you're airborne, watch the 840-pound main landing gear assemblies flip forward and up with amazing speed, even though they may be working against a 180 m.p.h. drag. Fast landing gear retraction gives you an extra margin of take-off safety because "clean" aircraft have better flight characteristics.

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This same principle... using *linear* motion to produce *rotary* motion... may have undreamed-of applications in *your* product. The Valve Division can work with you to engineer adaptations of these Thompson "Rotocaps" in dime-size units for delicate machines or as rugged giants for heavy machinery.

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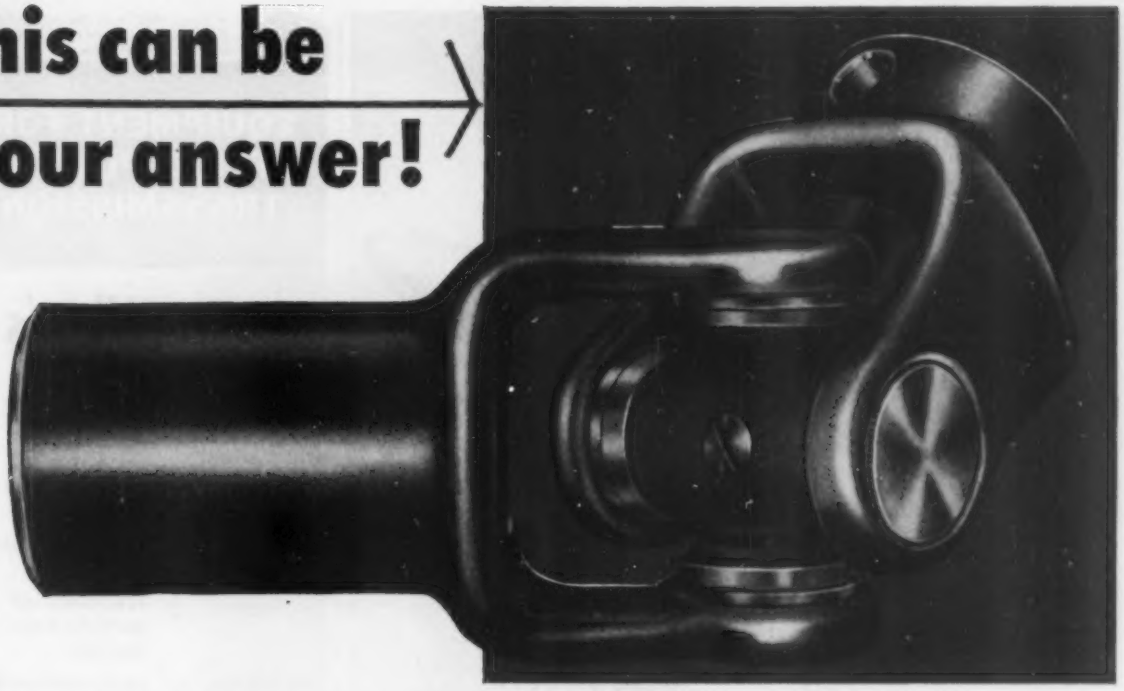
VALVE DIVISION

Thompson Products, Inc.

DEPT. VE-11 • CLEVELAND 17, OHIO

this can be your answer!



it's the NEW needle-bearing Series L12N

BLOOD BROTHERS Universal Joint

If you need a joint that's compact and sturdy— for transmitting a rated 3300 torque inch pounds* — this *new* needle-bearing Series L12N is precisely your answer!

You can order joints only — with standard or slip-type hubs — for round or square shafts. Or you can get complete assemblies similar to other Blood Brothers' catalog models. Swing diameter is only 2⅞" . . . the L12N easily clears a 3" space. Joints are available either factory prepacked or with lubrication fittings.

Tough, accurate forgings plus rigid standards of workmanship assure excellent performance and long life.

Why not get these advantages for the products you build? *Investigate the top-quality, competitively-priced Series L12N — today!*

*For rule-of-thumb estimates, figure approximately 5 HP per 100 RPM.

For torque loads common on:

FARM IMPLEMENTS

Mowers, corn pickers, small combines, windrowers, etc.

CONSTRUCTION MACHINES

Road graders, heavy dump bodies, etc.

SMALL INDUSTRIAL TRUCKS

— and other applications.

SLIP JOINT

PLAIN JOINT

BLOOD BROTHERS machine division

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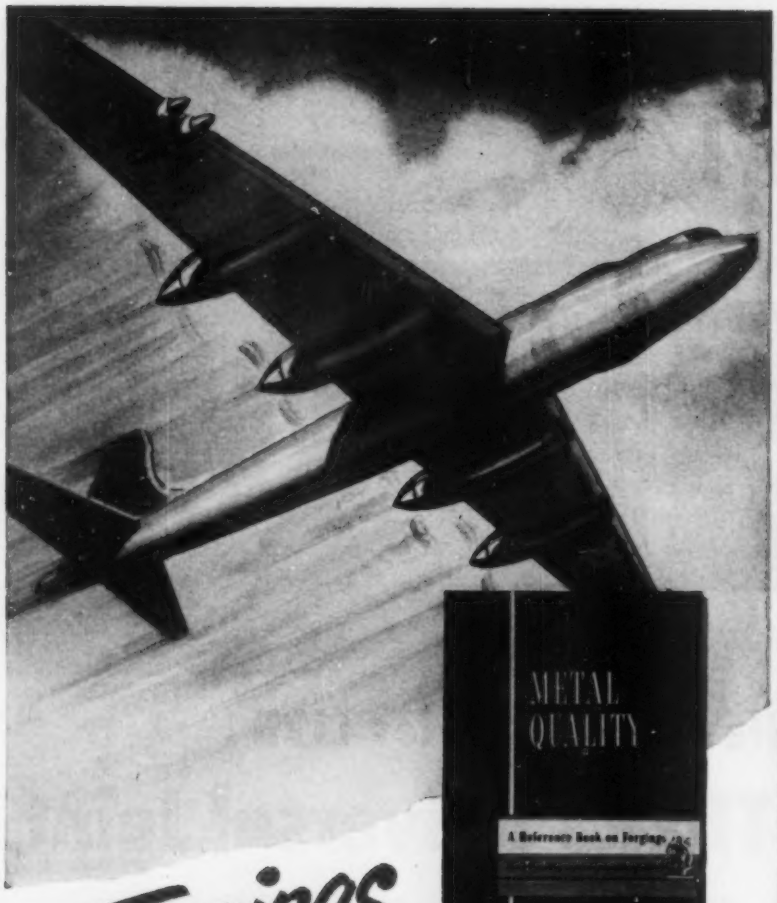

Forgings

Engineering, production and economic advantages obtainable with closed die forgings are presented in this Reference Book on Forgings. Write for a copy.

combining strength with unmatched toughness, are indispensable to the operation of all types of aircraft

. . . especially those types that are used for the defense of our country. A product fortified with the metal quality found in forgings outperforms other products. Forgings are used for the toughest work loads. Check all the parts, particularly those which are subject to greatest stress, that make up your product. Check these parts with the aid of Problem Parts Attack Charts which are available upon request. These charts reveal the unrivaled economic and mechanical advantages of closed die forgings and relate them to specific engineering and production problems. Then consult a Forging Engineer about the correct combination of mechanical properties which closed die forgings can provide for your product.

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**Roller mechanisms permit higher speeds with any oil than most displacement designs.*

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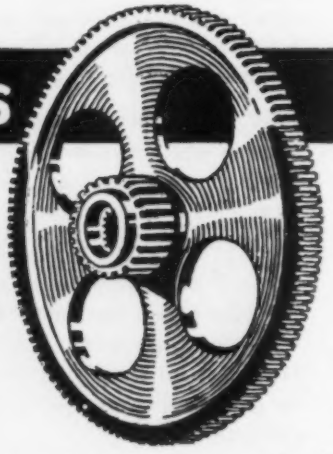

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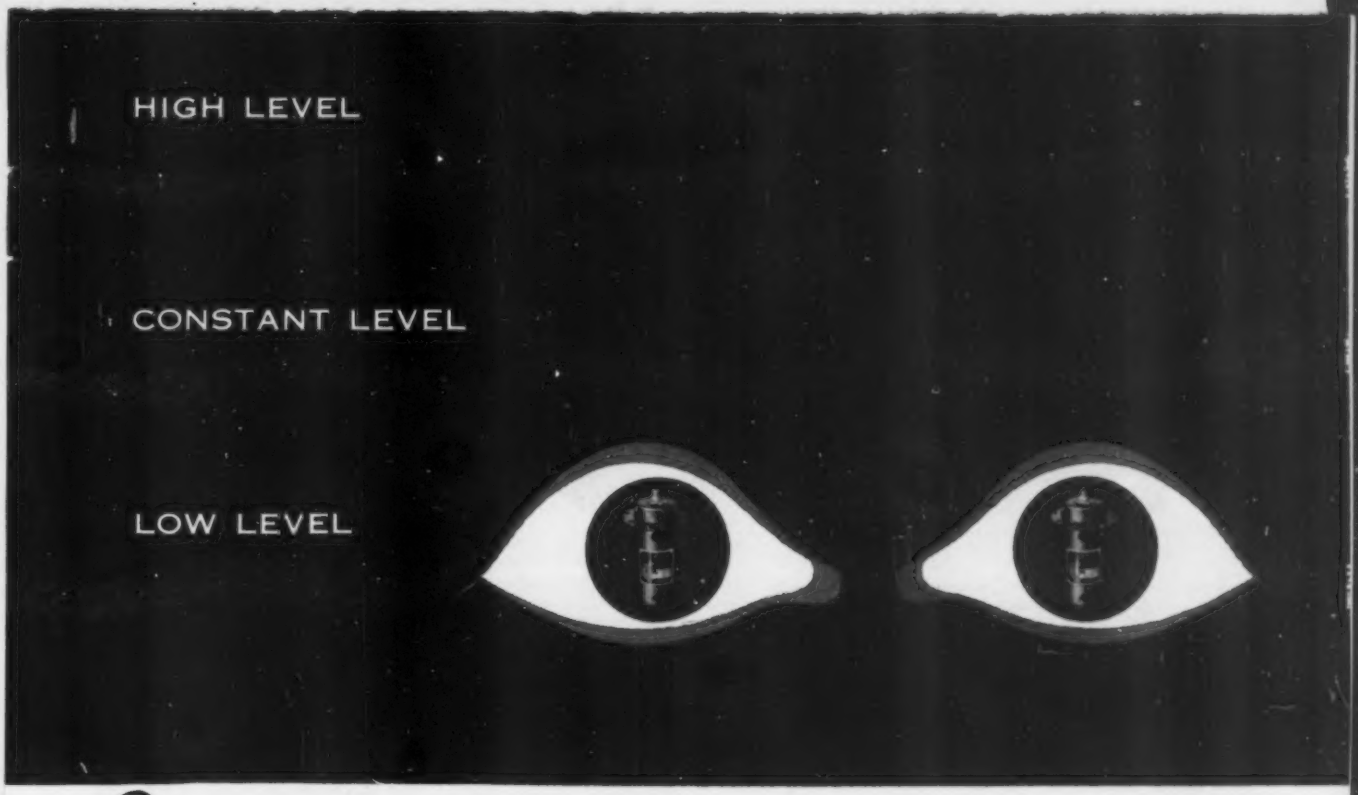
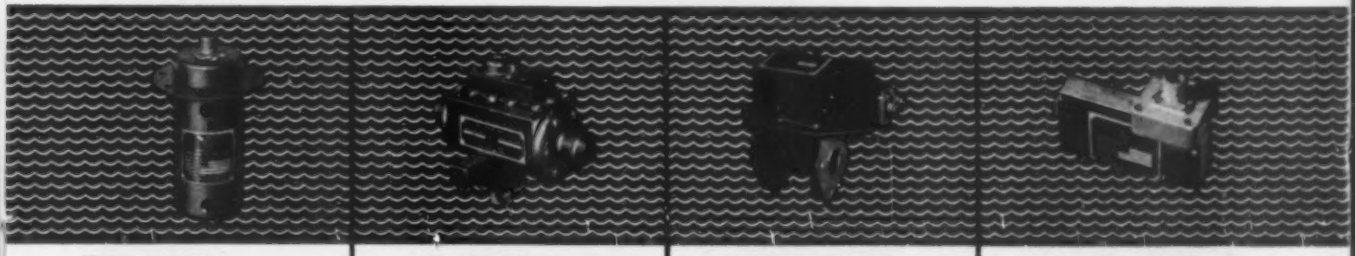


Revere INSTRUMENTS SEE WHERE YOU CAN'T

See *Revere* . . . if you need to know — **HOW MUCH LIQUID — HOW LITTLE — AT WHAT LEVEL.** *Revere's* precision made instruments are your unfailing eyes that see into sealed tanks, tubes or complex fuel lines. They can provide you with accurate measurement of liquid level regardless of pressure or temperature changes, vibration or rapid acceleration forces, AND they will automatically transmit a warning signal whenever liquid flow or level maintenance varies from a pre-determined value.

These hermetically sealed, magnetically actuated instruments employ balanced float assemblies to minimize false alarms. Compact and light, Revere instruments meet government specifications. They are available in many different configurations, some of which include relays to handle heavy electrical loads. Others are designed for complete submersion in fluids.

*Submit your control problem to our Field Engineering Department today. Revere will provide the instruments to tell you — **HOW MUCH — HOW LITTLE — AT WHAT LEVEL.** Shown below are some instruments that are the seeing-eyes of aircraft and industry.*



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Specially designed with single or dual float systems to provide automatic cut-off control for single point high pressure refueling.

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INDICATING SWITCH
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FLUID LEVEL SWITCH
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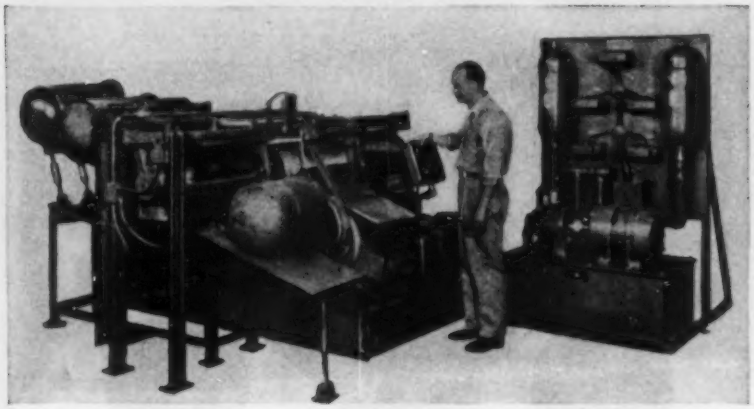
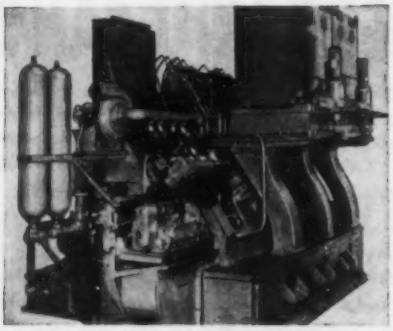
GREER TOPICS

Functions and Applications of the Greer Accumulator



Bunell's automatic cylinder trimming and forming machine incorporates two Greer accumulators to cut motorpump unit size by 50%. Slashed cost $600, weight 400 pounds and saved substantial floor space. Simpler circuit used few fittings for less maintenance.

How Greer Accumulators Reduce Power Requirements



Kreuger's huge Insert Valve Press uses 4 Greer accumulators to supply power needed to insert valves in auto cylinder blocks. The Greer accumulator reduced motor and pump requirements and assured the smooth, even flow of oil under pressure on circuit demand.

They store tremendous power in small space—deliver it instantly on demand of hydraulic system

As a primary source of hydraulic power where the work cycle does not depend on the flow of the pump or as auxiliary power in intermittent duty systems, the Greer accumulator has its most dramatic effects. In these applications, the Greer accumulator can save a great deal of power, reduce size and cost of equipment, and develop a much more efficient hydraulic circuit.

This compact and economical power package, with its unmatched ability to store power in small space, accumulates energy from the pump and delivers it instantly as required by the circuit, permitting small motors to do the work of big ones. For practical applications, read about the installation of Greer accumulators on the equipment as shown in photographs above and on left.

Greer's staff of expert hydraulic engineers are available for a discussion of your problem without obligation. Call or write Greer today.

Greer Hydro-Pneumatic Accumulators have many other diversified functions

(1) Pressure storage chamber for main, auxiliary and emergency power (2) Pressure-volume compensator for leakage and temperature (3) Dispenser of fluids and lubricants (4) Transfer-barrier for fluids and gases (5) Shock absorber for line shock and pump pulsation.

Precision engineered to make any hydraulic system better! Complete data and diagrams in Brochure 301. Write for your free copy.

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The Annual HANDBOOK of Product Design for 1954

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It's on its way to you as part of your regular subscription to *Production Engineering*. Keep it handy, along with last year's HANDBOOK, where it will serve you time and again in your work through the months and years ahead.

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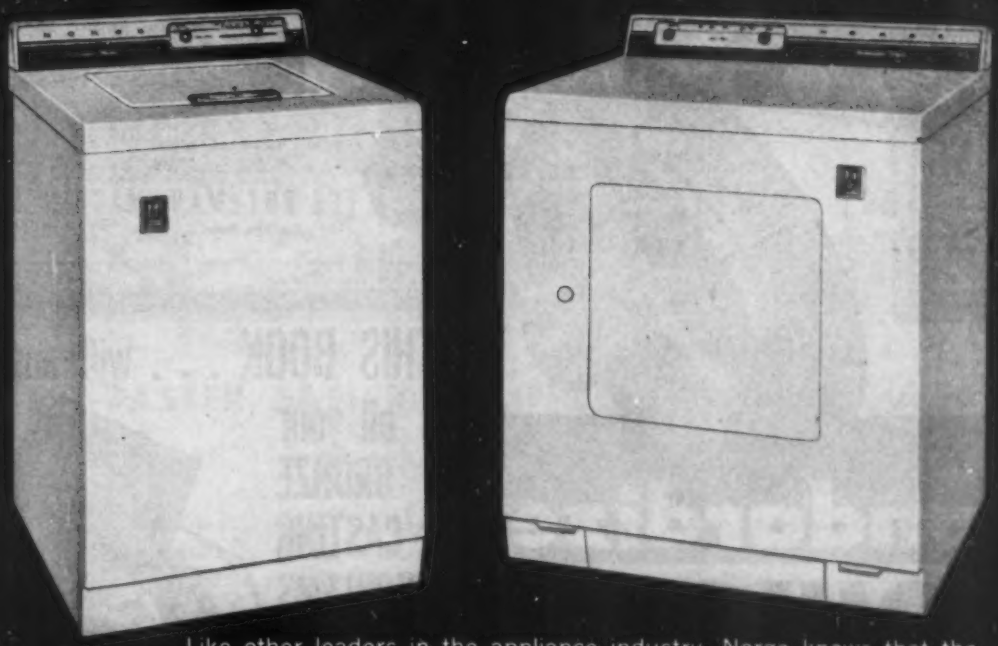
You'll find the new HANDBOOK even more complete, more useful, easier to use than last year's tremendously popular issue. Watch for it *this month*.

NORGE knows how SORENG components reduce REAL costs—DO YOU?

Norge specifies 6 Soreng components for the Time-Line "Laundry Maids"



Like other leaders in the appliance industry, Norge knows that the real cost of a component is its cost per year of service life. So low first cost must always be tempered with "how long will it last?"

By this yardstick Soreng measures well indeed. Whether you need solenoids or switches, timers or terminals, valve coils or other appliance controls, you'll find our products deliver highest quality at lowest production costs.

To be sure your new model will be competitive, write for specific information or, better still, consult with our engineers at the earliest design stage.

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Plants: Schiller Park, Ill., Fremont, O., Spring Valley, Ill.

Specialize

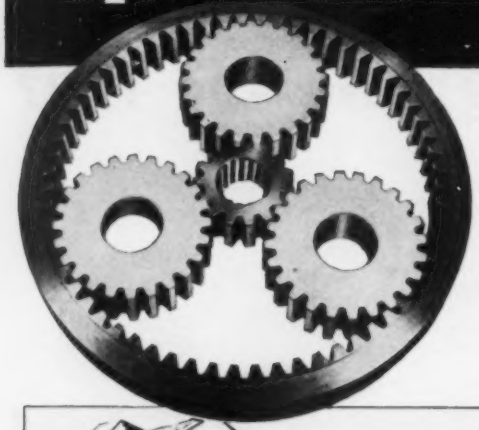
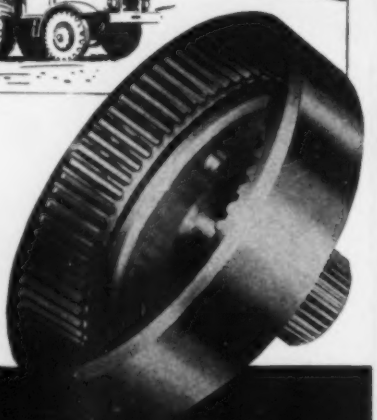


Photo shows planetary gear system assembled.

Pictured above is Euclid Road Machinery's immense 25 or 40 ton coal hauling equipment using planetary gears.

Photo at right shows an alternate design of the sturdy planetary gear carrier.



Standardize

GEARS OHIO REDUCERS

Ohio Gears are at work in all their glory when operating for Euclid Road Machinery, world's leading manufacturer of heavy duty coal haulers and earth moving equipment. Here's where gear engineering, strength and durability meets its test, on long hauls, up and down steep grades, forward and backward over broken terrain, at any angle, pushing and pulling 25 or 40 ton loads on 4 wheel planetary gear drives, at various speeds, tensions and stresses. All this on Ohio Gears, every day, year in and year out, with engineering in every ounce of metal and every measurable gear dimension . . . Euclid Road Machinery demands dependable gears. Perhaps your products need such mechanical insurance. See our nearest distributor or write direct.

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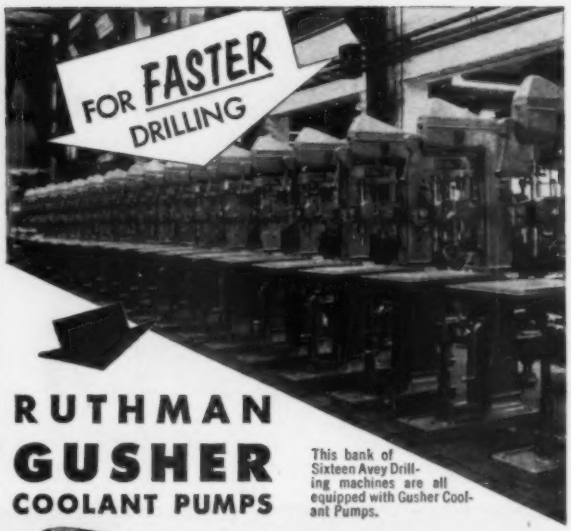
OHIO GEARS



RUTHMAN GUSHER COOLANT PUMPS

This bank of Sixteen Avey Drilling machines are all equipped with Gusher Coolant Pumps.

In choosing a coolant pump for your metal cutting machinery it pays to standardize on the *best*, a Ruthman Gusher Coolant Pump. Leading machine tool manufacturers have learned by experience that Gusher Coolant Pumps are precision built to give better service, and greater production. That's why so many of them use Gusher Pumps exclusively on their machines.

Always specify Gusher Coolant Pumps—You'll eliminate coolant problems.

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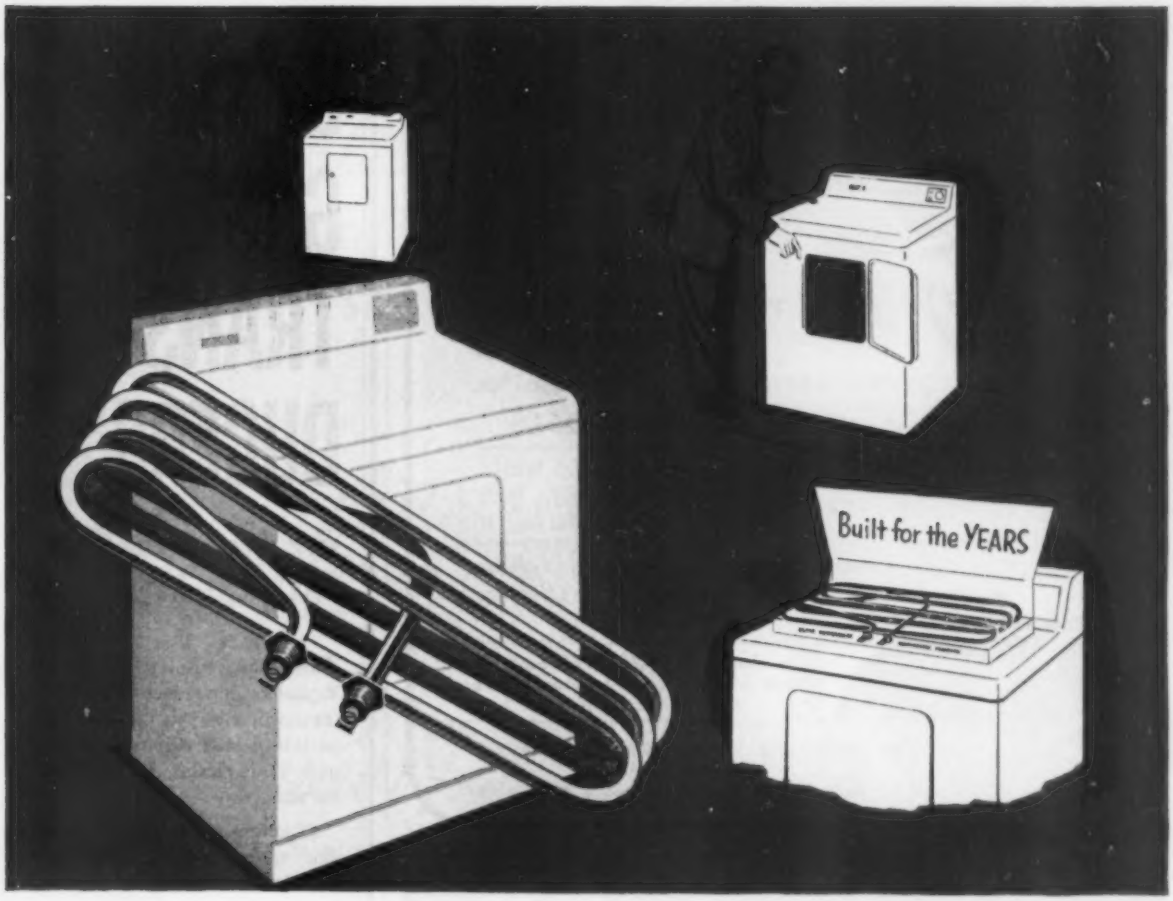
Established 1909



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equip with TK® Rod-type heating units

That *competitive advantage* you are seeking this next year could well be the use of TK Rod-type heating elements. Granted, they'll probably cost more—and this fact may deter some manufacturers from adopting them. But think of the *sales pluses* you get—for as little as 40 to 50 cents added to the cost of your product.

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TK Units for DISHWASHERS, Too!

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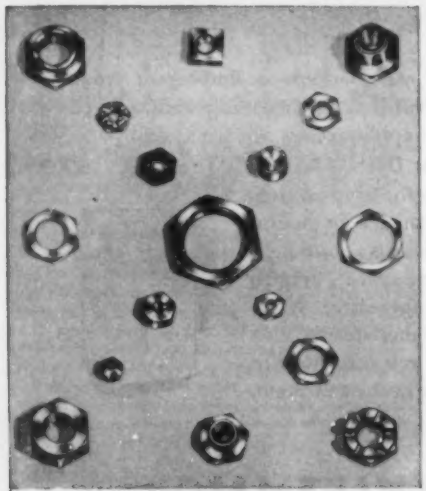

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For Measurement and Control

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The first of five sections in this special report covers the two classes of gage—bonded and unbonded, types of bridge circuit, amplifying and recording equipment and the systems combining these components. The four remaining sections take up the different types of transducers designed specifically for measuring pressure, flow, weight and displacement. Case histories follow each transducer section to illustrate some of the more unusual applications for strain gage transducers.

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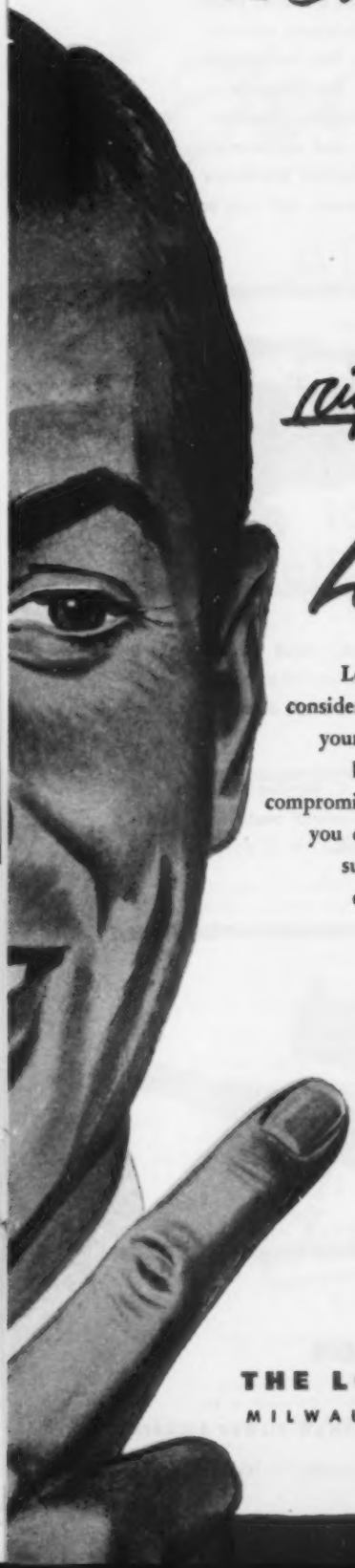

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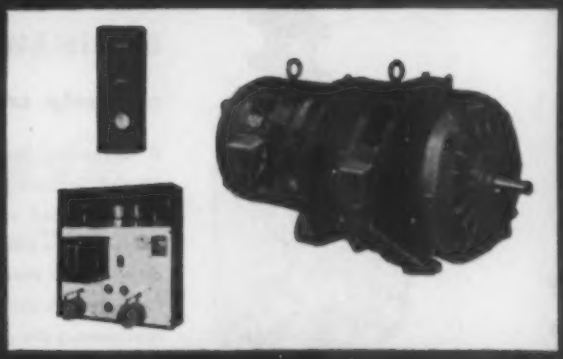

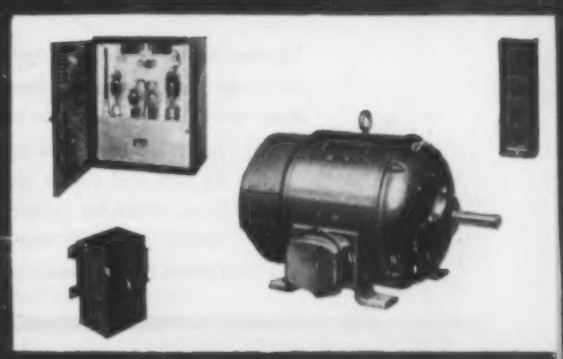

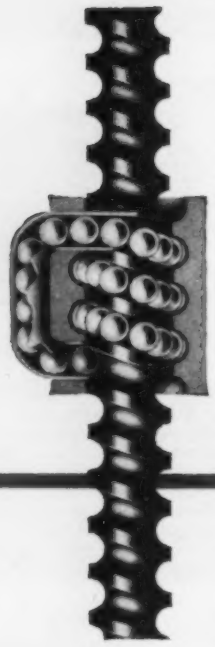

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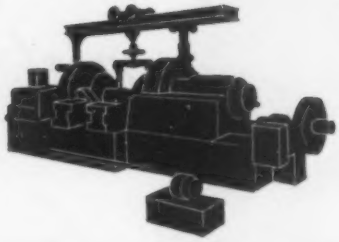

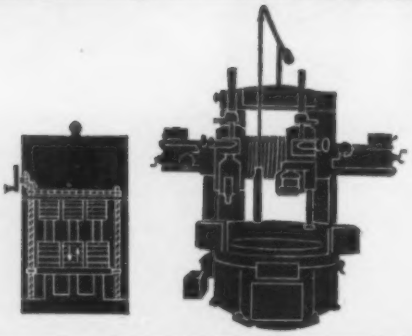

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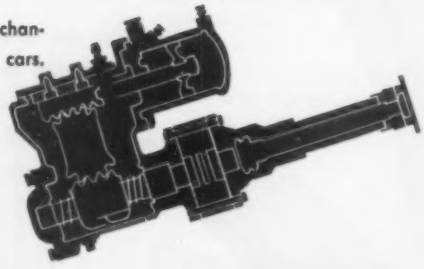

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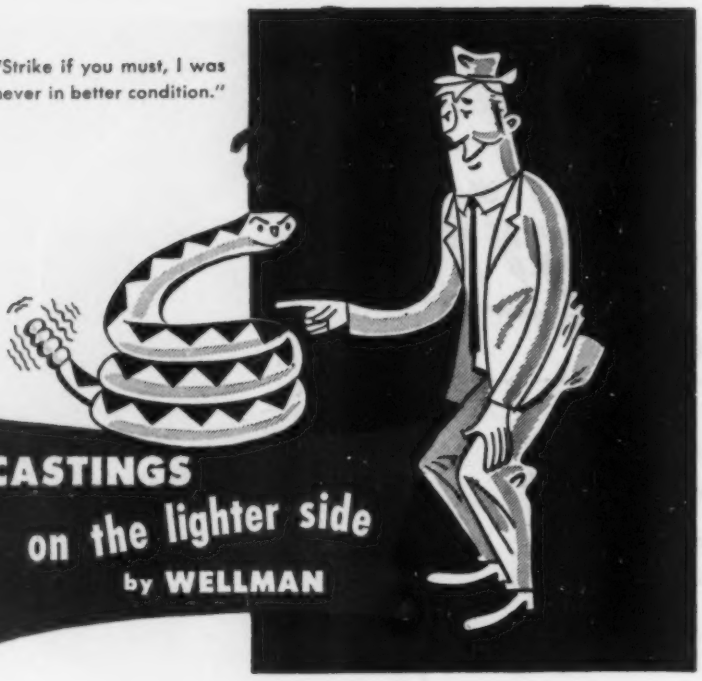

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on the lighter side
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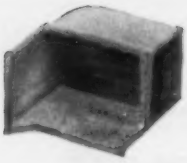

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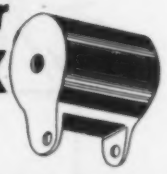
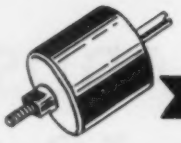
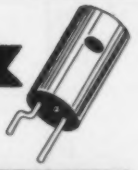




CAPACITORS

TRANSISTORS



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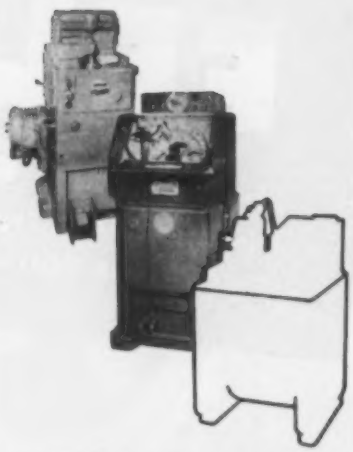

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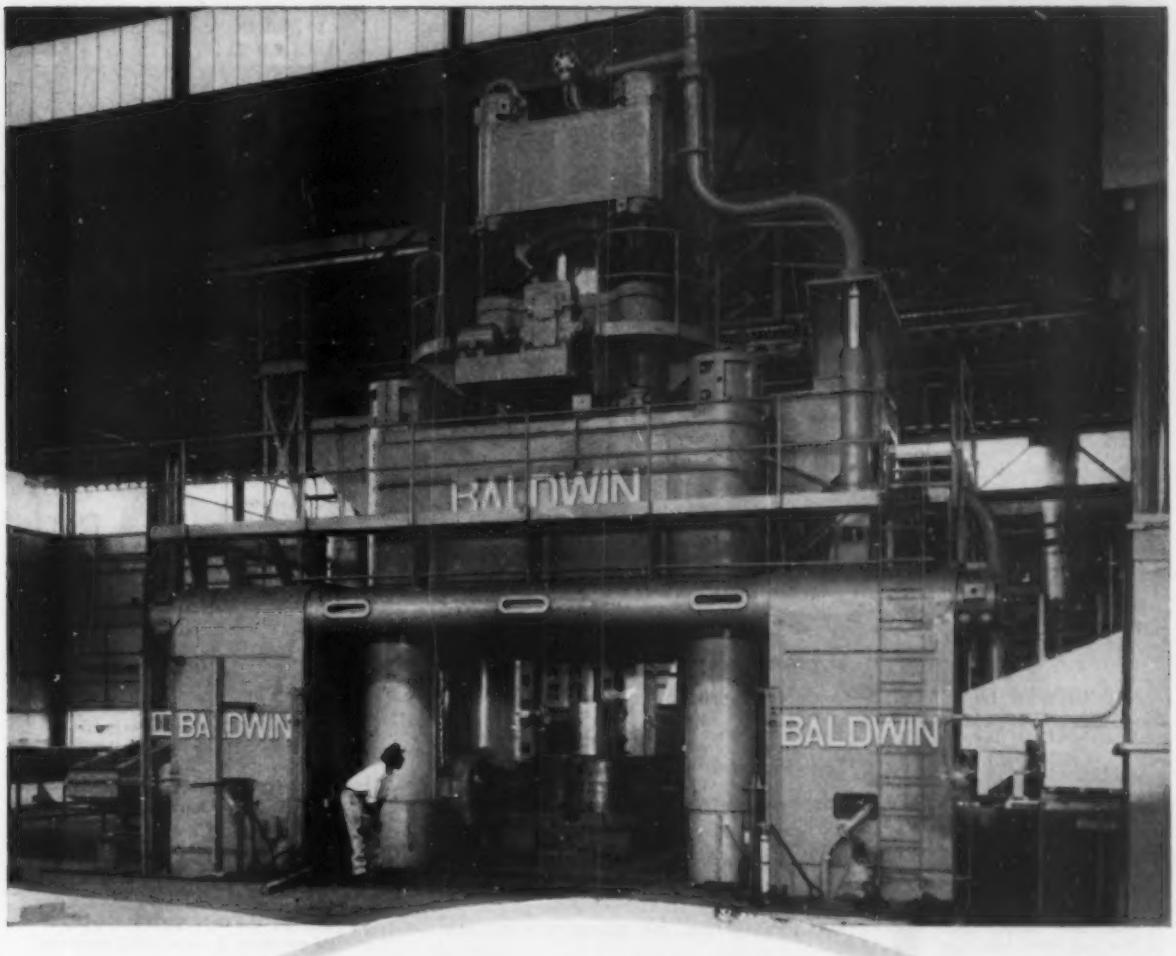

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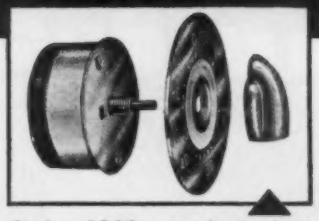

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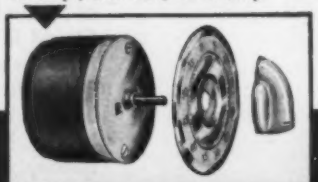
Series 6700-6800-6900 — Heavy duty, 2 circuit time switches, to break circuits either after different time intervals or simultaneously at end of same interval. 6700 Series for dishwashers, hair driers, etc.; 6800 Series primarily for battery chargers; 6900 Series for heavy duty circuits in clothes driers. Time periods range from 60 seconds to 5 hours. Electrical data: UL approved — 6700 and 6800, 20-amp., 125 volt, 1 H.P. or 10-amp., 250 volt, A. C. only; 6900, 28-amp., 250 volt, A. C. only.



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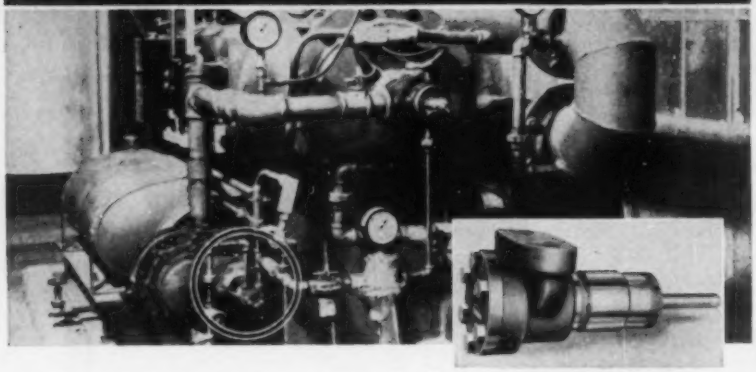
HOW ROOTS CONNERSVILLE USES THOUSANDS OF VIKING PUMPS



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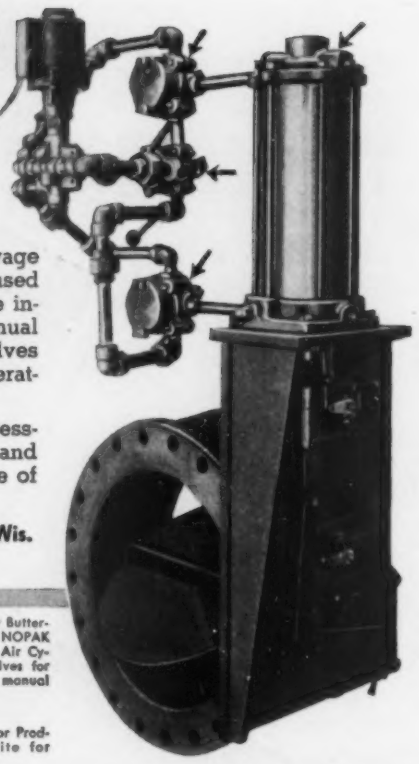

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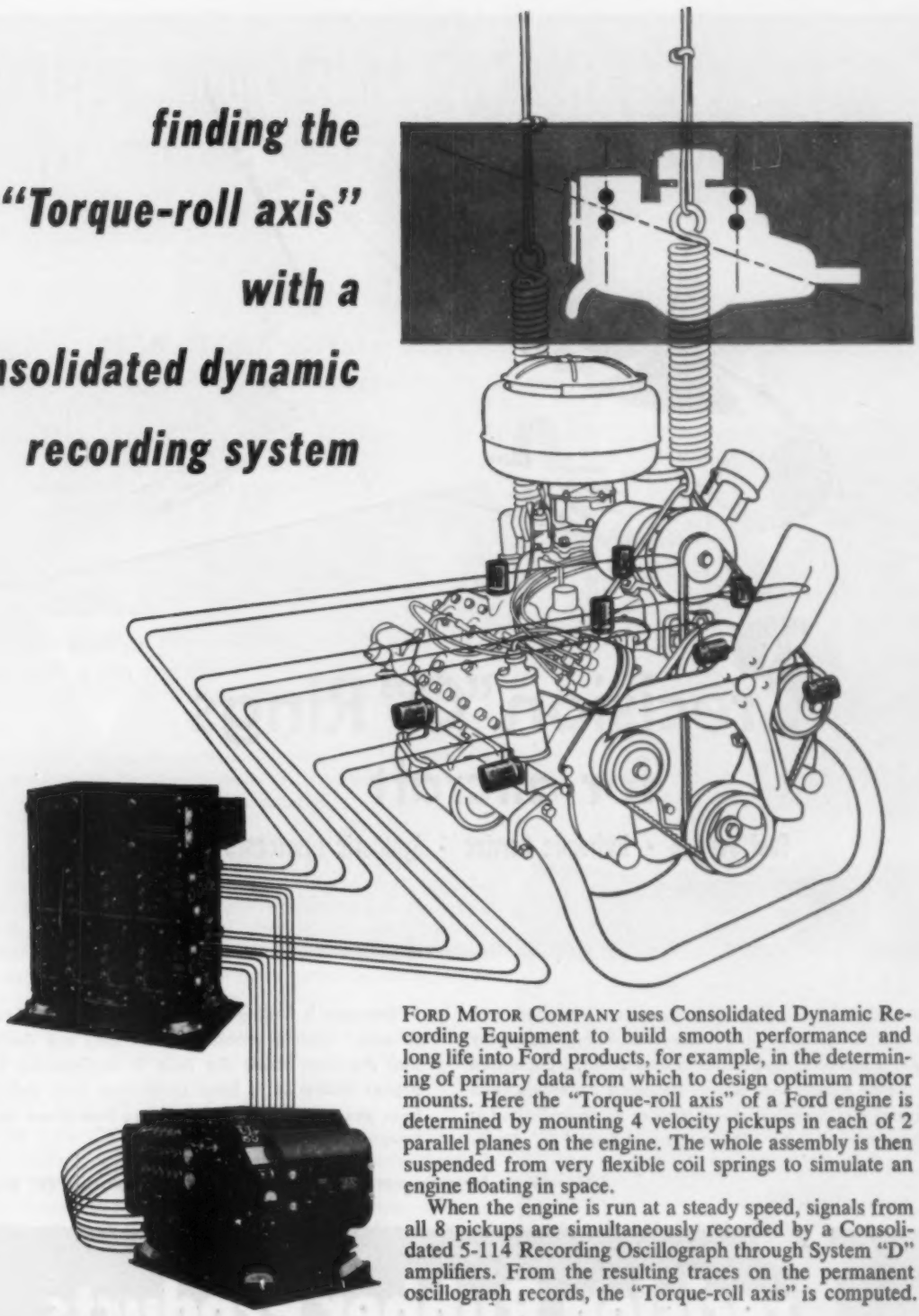
finding the "Torque-roll axis" with a Consolidated dynamic recording system



FORD MOTOR COMPANY uses Consolidated Dynamic Recording Equipment to build smooth performance and long life into Ford products, for example, in the determining of primary data from which to design optimum motor mounts. Here the "Torque-roll axis" of a Ford engine is determined by mounting 4 velocity pickups in each of 2 parallel planes on the engine. The whole assembly is then suspended from very flexible coil springs to simulate an engine floating in space.

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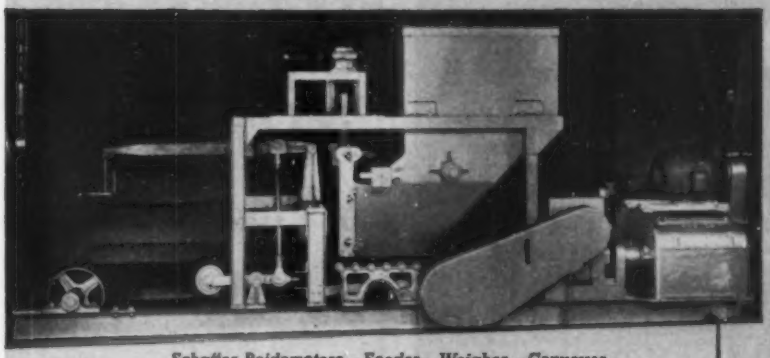
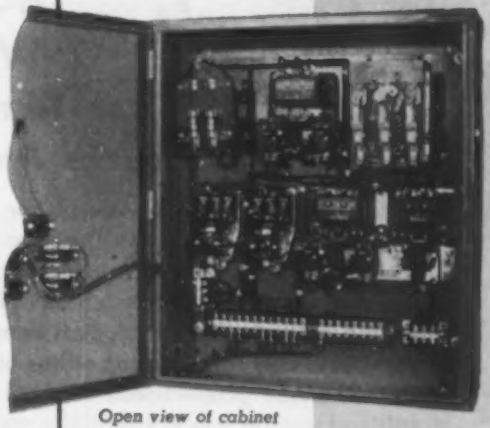
SCHAFFER POIDOMETERS rely on CLARK CONTROL for accurate feeding, weighing and conveying

CLARK Type "CY" Starters *are basic units in Control System*



Schaffer Poidometers—Feeder—Weigher—Conveyor

Closed view of Clark Control Cabinet



Open view of cabinet

Dependable, accurate control is essential on poidometers designed to deliver materials to machines or process operations in exactly correct amounts.

The Schaffer poidometer illustrated is one of four which feed clinker and gypsum in lump state to a ball mill for pulverization. The CLARK control panel incorporates controls for two motors—one operating the conveyor belt at a fixed travel speed, the other operating the hopper gate. A weighing beam actuates limit switches, causing controlled motor to move gates up or down, to keep proper weight of material flowing.

When two or more poidometers are used for proportioning materials, controls are provided so that stoppage of one machine automatically stops the others to prevent improper proportioning.

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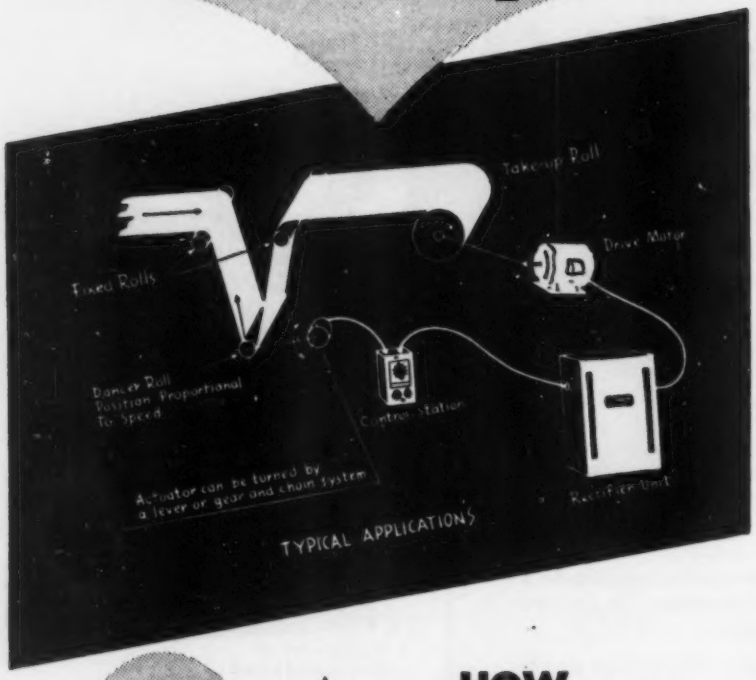

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A small tension change positions the actuator shaft so as to call for motor speed change to restore preset tension. Thus a constant linear feet per minute windup may be achieved even though the radius of takeup roll increases with each turn to otherwise increase linear speed versus radius build-up. Speed is now made proportional to position of dancer roll and tension is held essentially constant, as is the linear rate of material travel.

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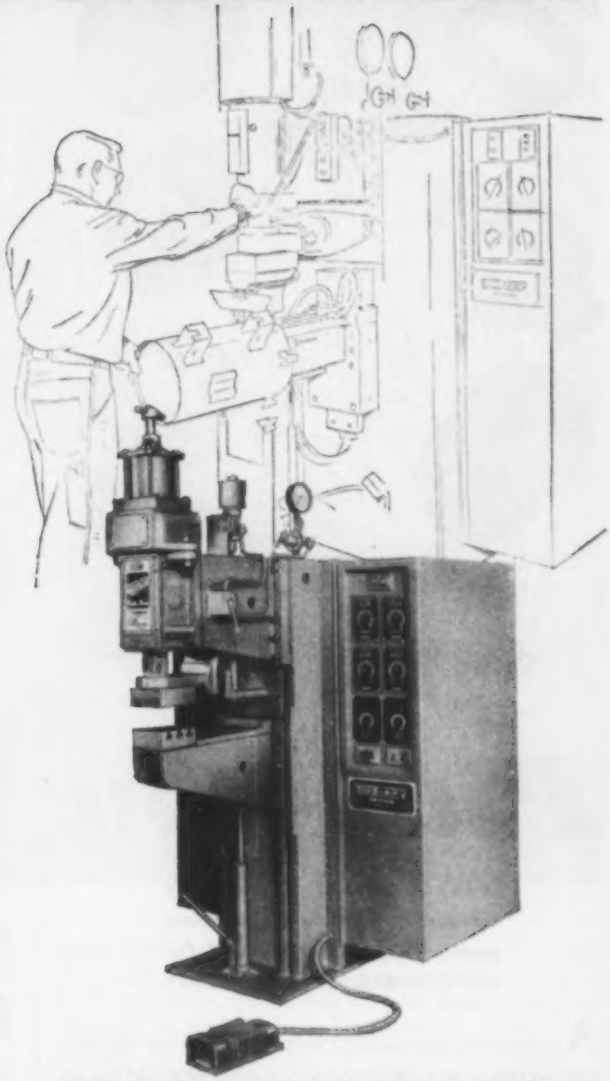
SEVEN DIFFERENT PRODUCTION OPERATIONS ON ONE STANDARD WELDER



Versatile Sciaky Standard Three-Phase Projection Welder Sharply Reduces Tooling Costs

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For complete details on the efficiency and economy of Sciaky resistance welding at Moloney, write for "Resistance Welding at Work", Volume 3, No. 7.

*Sciaky type PMCO 2T Three-Phase Projection Welder joins seven different parts to Moloney Transformer Tanks. A two-switch foot pedal provides immediate selection of preset heat and pressure sequences for different welds without removing tank from welder or stopping production to reset controls.

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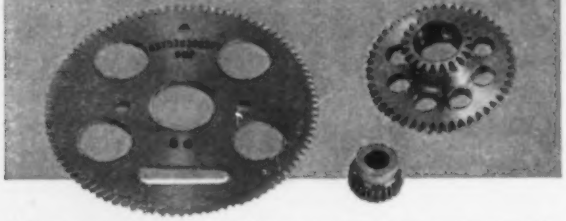

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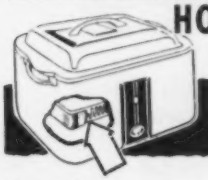

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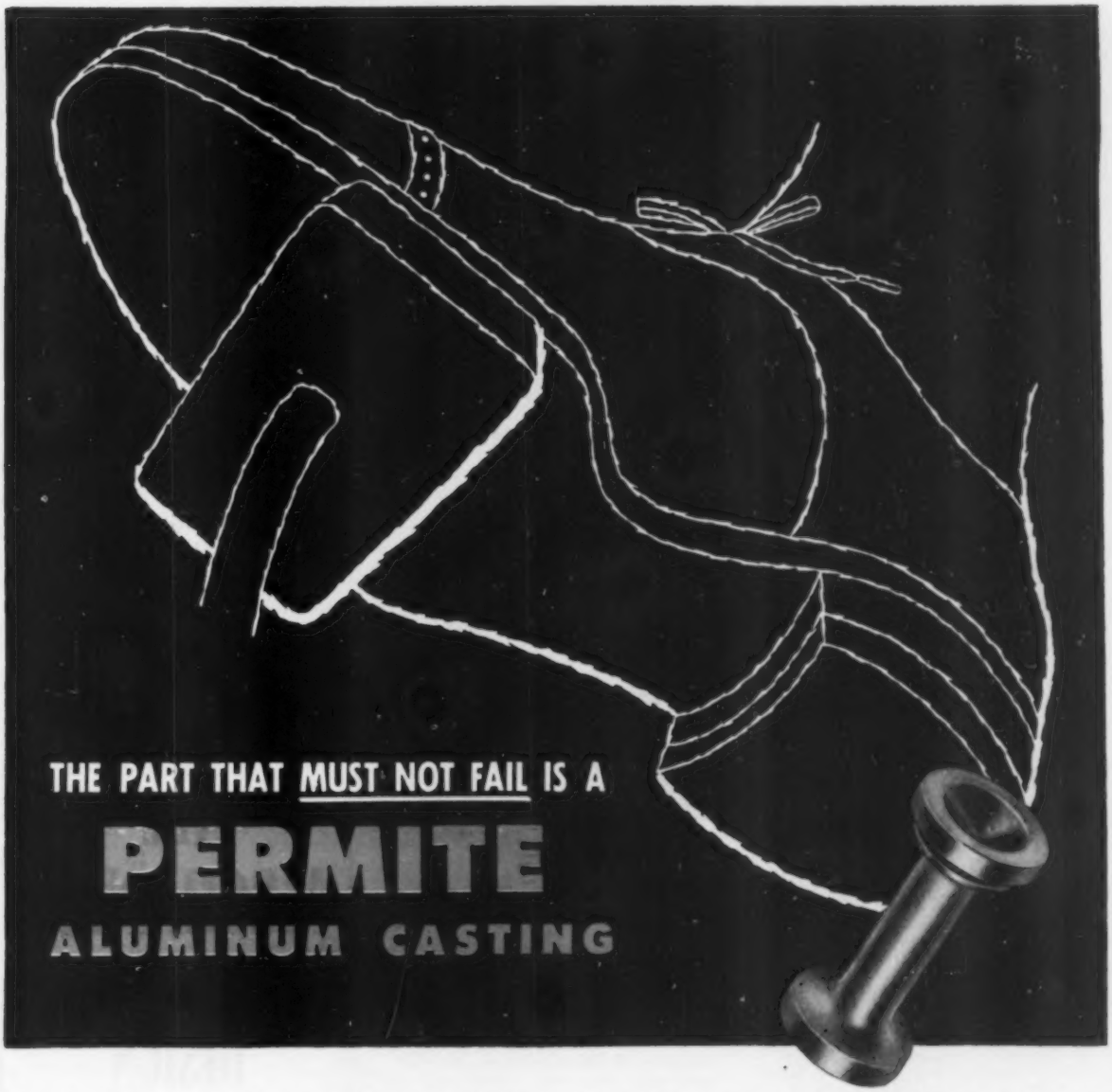

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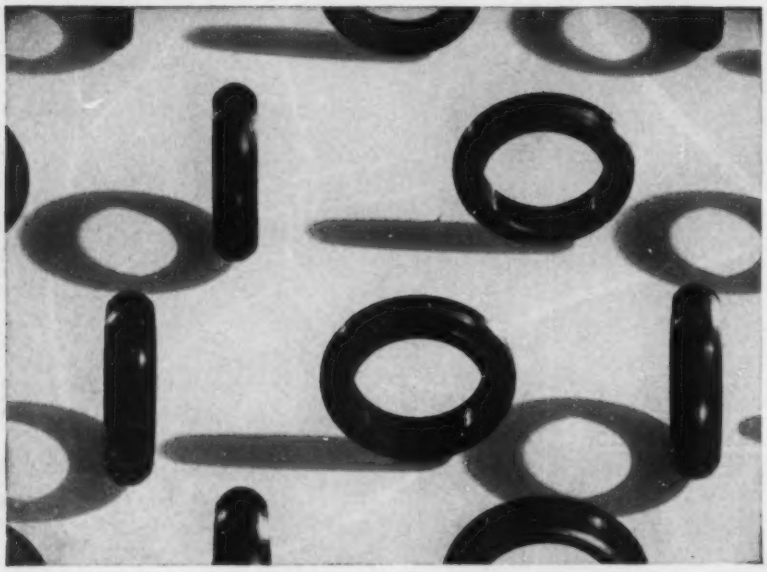

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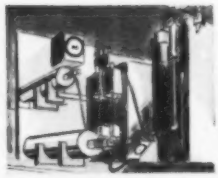
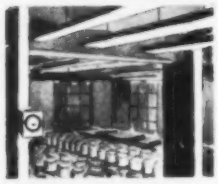


Laboratory life testing.



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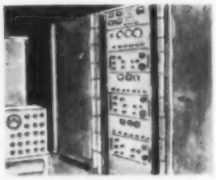

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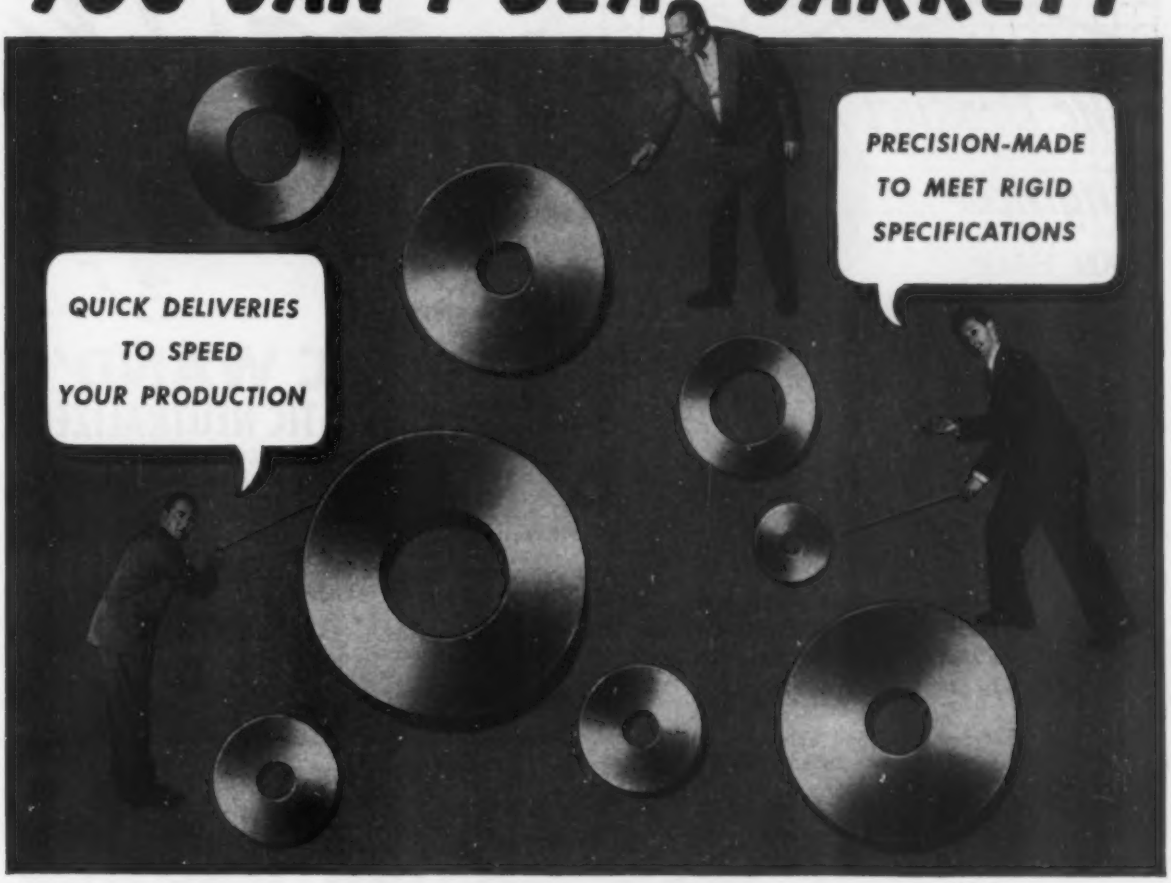

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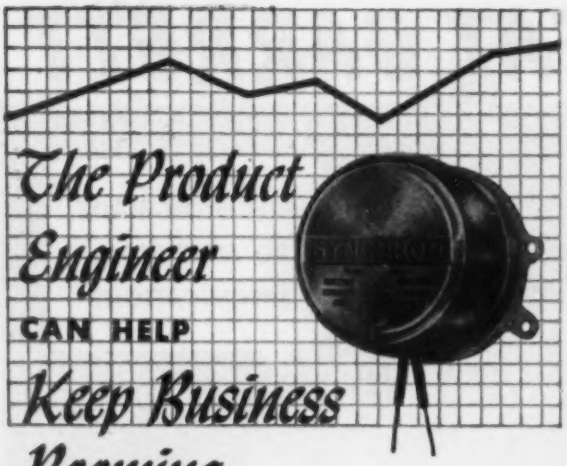

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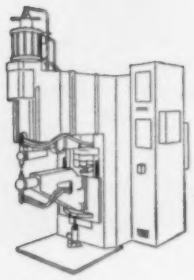

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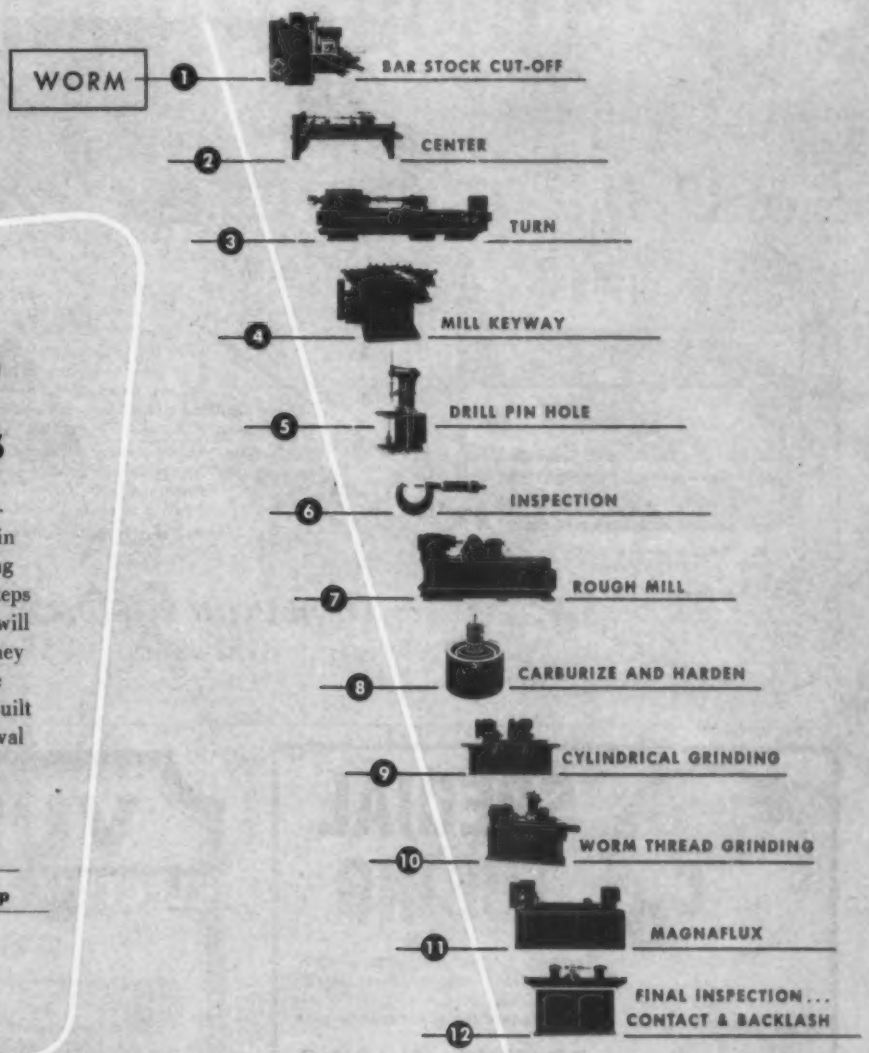

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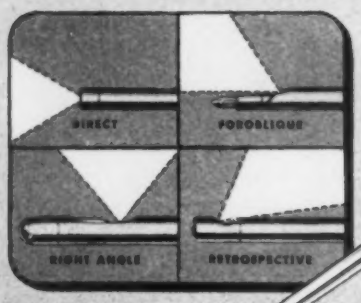

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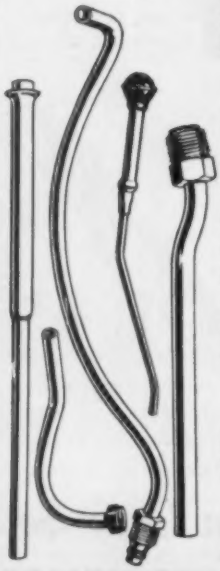

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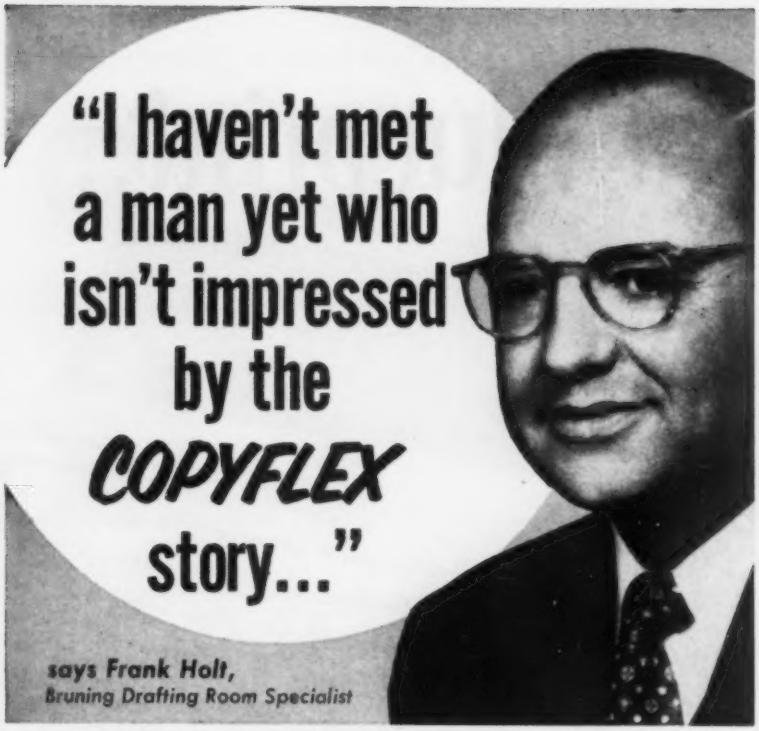

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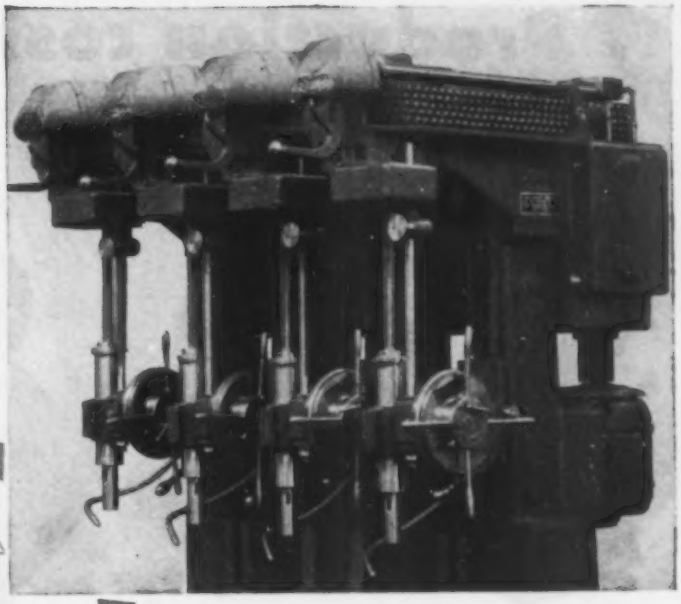

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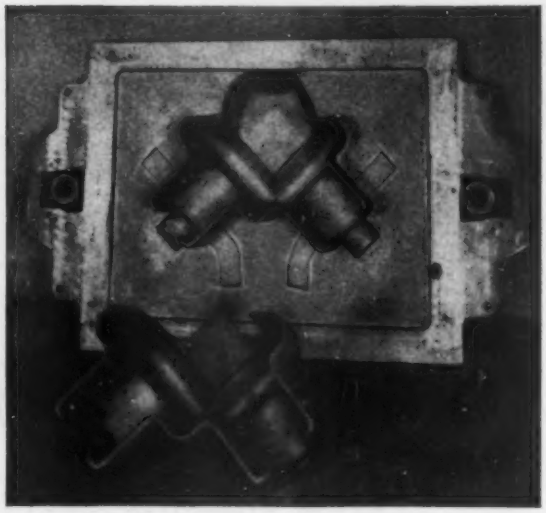

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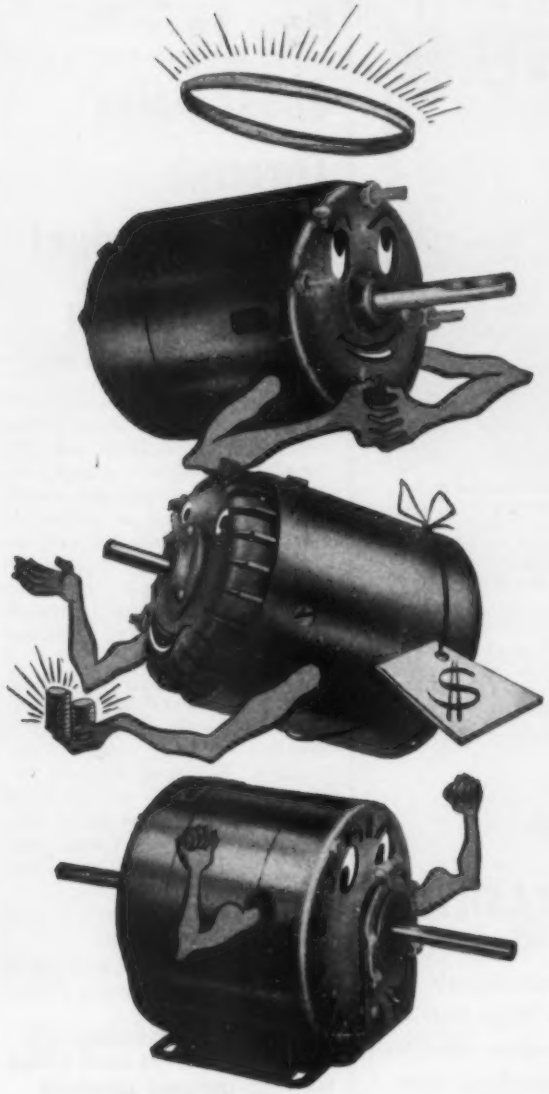

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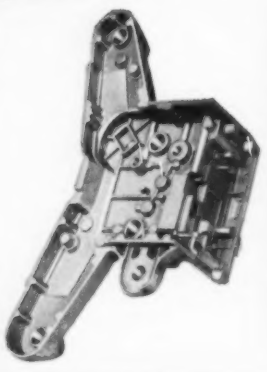

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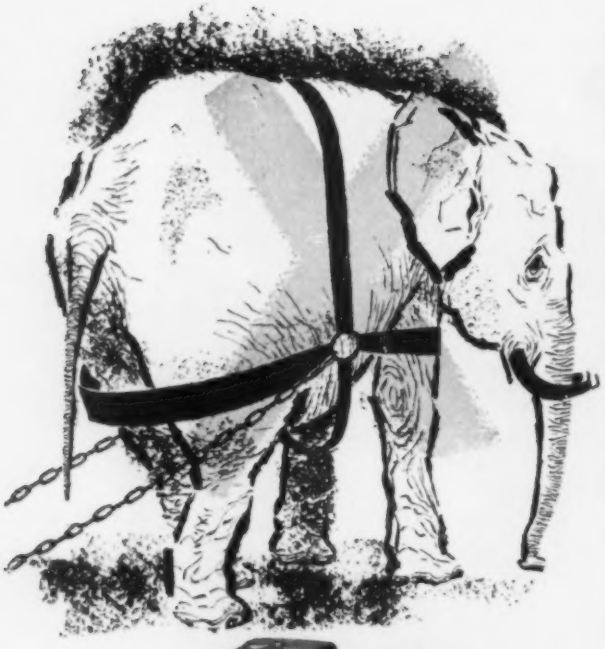

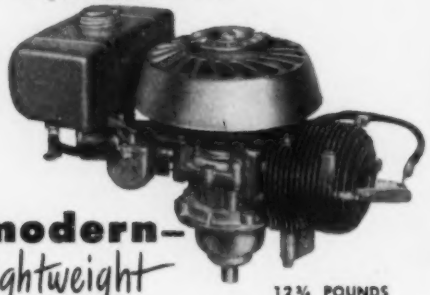

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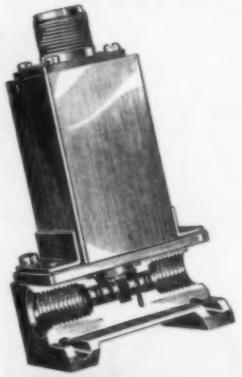

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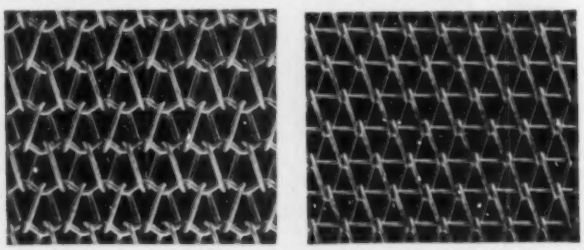

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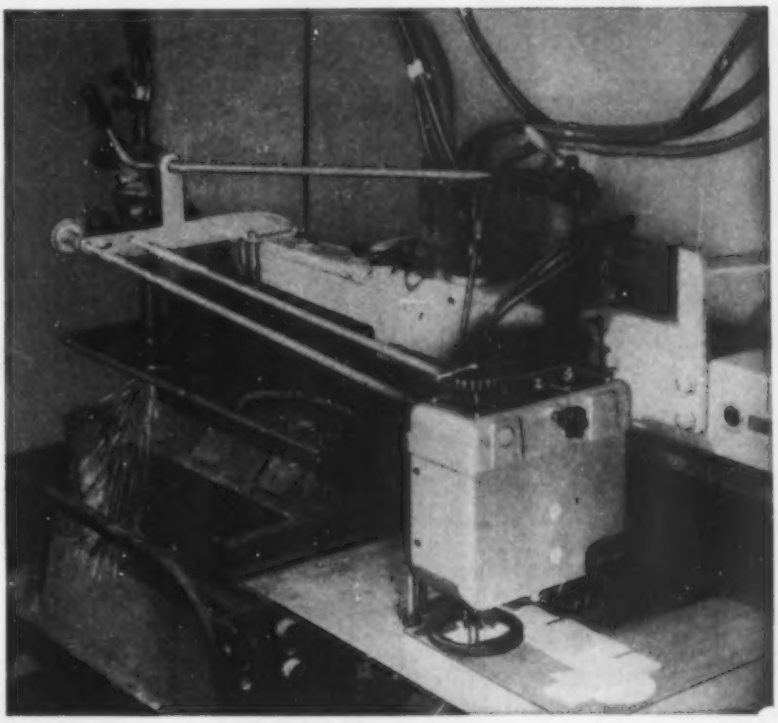

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The terms "Linde" and "Oxweld" are registered trade-marks of Union Carbide and Carbon Corporation.

to OEM

Designed and Built

for your Specific job

Brady Pumps

We welcome your pump problems and inquiries. The answer to your problem may be in the files of our Engineering Department. For three generations, Brady has specialized in the design and manufacture of small Centrifugal Pumps . . . used as original equipment by leading manufacturers in Air Conditioning, Refrigeration, Dairy, Machine Tool and many other Industries.

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What FEATURES do YOU WANT in a UNIVERSAL JOINT?

- Maximum strength and bearing surface
- Quick-acting, dependable response
- Long service-life
- Optimum operating angle
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- Accurate surface grinding
- High concentricity
- Minimum weight

LOVEJOY HAS THEM ALL!

Availab'e in 13 standard sizes—diameters ½" to 4"—bore ¼" to 2"—lengths 2" to 10⅝"

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Manufacturers of flexible couplings, universal joints, varicb'e speed pulleys and variable speed transmissions.

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DROP FORGINGS

. . . any size or shape up to 200 lbs.

Whatever your requirements in forgings, Herbrand is your most faithful source of supply as it has been for hundreds of industries since 1881. Your inquiries are solicited.

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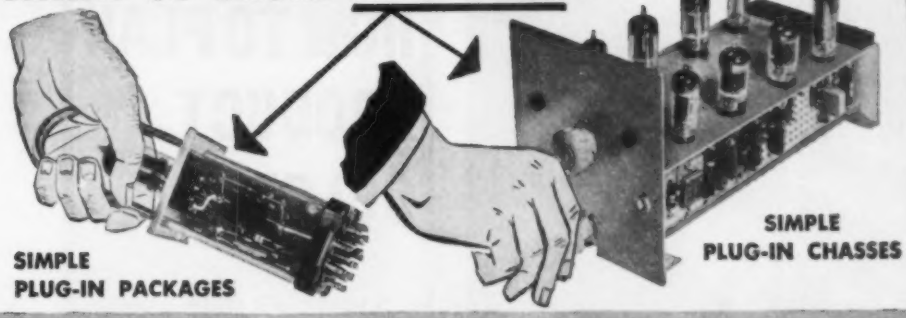
THE BINGHAM-HERBRAND CORPORATION

FREMONT, OHIO

In visualizing AUTOMATIC ELECTRONIC CONTROLS for your equipment, think of them LIKE THIS



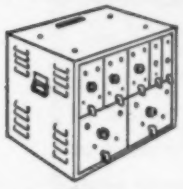
Are your prospects afraid of the "Little Black Box?"

Your wonderful new Electronic Controls may mean the death of a sale — unless the cautious buyer sees that his own personnel can locate and correct Control troubles on the spot.

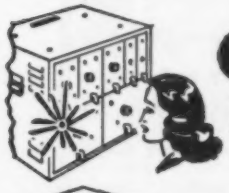
Any electronic equipment can now be subdivided into simple plug-in units that for the first time assure your users RELIABILITY IN SERVICE

(The User's own personnel can locate and correct most troubles on the spot)

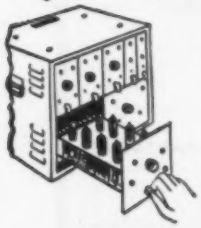
Here are the bold new Standards:



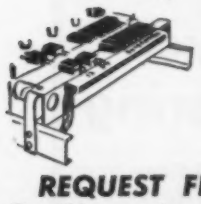
1 Circuitry subdivided, function by function into plug-in units.



2 Tiny telltales spot trouble instantly.



3 Plug in replacement spares in 30 seconds.



4 All leads brought to single accessible point of check — all numbered, color-coded — so layman can make first-level tests.

REQUEST FREE HANDBOOK

Describing complete system of Plug-in Unit Construction and Components. 226 pages and many Planning Sheets.

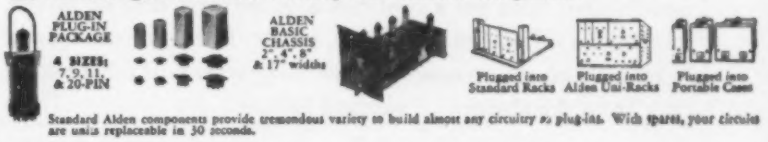
Here's how to get them: IT'S AS SIMPLE AS THIS –

1. ***Unitize your circuitry in compact vertical planes using Alden Terminal Card Mounting System.***

PREPUNCHED TERMINAL MTG. CARD
MINIATURE TERMINALS
JUMPER STRIP Eliminates wiring for common circuits
CARD-MTG. SOCKETS
YOUR COMPLETED CIRCUITS FOR PLUG-IN PACKAGE OR CHASSIS

You can use Alden Terminal Mounting Card with Alden Miniature Terminals, Jumper Strip and Sockets staked to accommodate any circuitry — making complete units ready for housing. Components snap into unique Alden Terminals, are held ready for soldering.

2. **To mount this vertical circuitry, ALDEN PLUG-IN PACKAGES AND BASIC CHASSIS give tremendous variety with standard components**


ALDEN PLUG-IN PACKAGE
4 SIZES: 7-9-11- & 20-PIN
ALDEN BASIC CHASSIS 2", 4", 8" & 17" widths
Plugged into Standard Racks
Plugged into Alden Uni-Racks
Plugged into Portable Cases

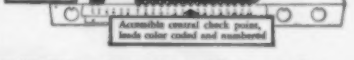
Standard Alden components provide tremendous variety to build almost any circuitry as plug-ins. With spares, your circuits are units replaceable in 30 seconds.

3. **Give chassis easily traceable interconnects and 30-second replacement with ALDEN SERVE-A-UNIT KIT**

IT'S AS SIMPLE AS THIS

Arrange Alden Side Rails (1) and Alden Lock Frame (2) to suit your chassis. Alden Serve-A-Unit Locks (3) mount in your chassis to engage pre-punched holes in Alden Lock Frame (2) to pilot, draw in, lock or eject your chassis. Arrange Alden Back Connectors (4) in orderly row on Alden Lock Frame. Mount mating Alden Back Connectors on your Chassis.

GIVING YOU 1) Chassis that plugs in, locks and ejects with half turn of the wrist. 2) leads so beautifully organized, accessible and identified that non-technical personnel can service.

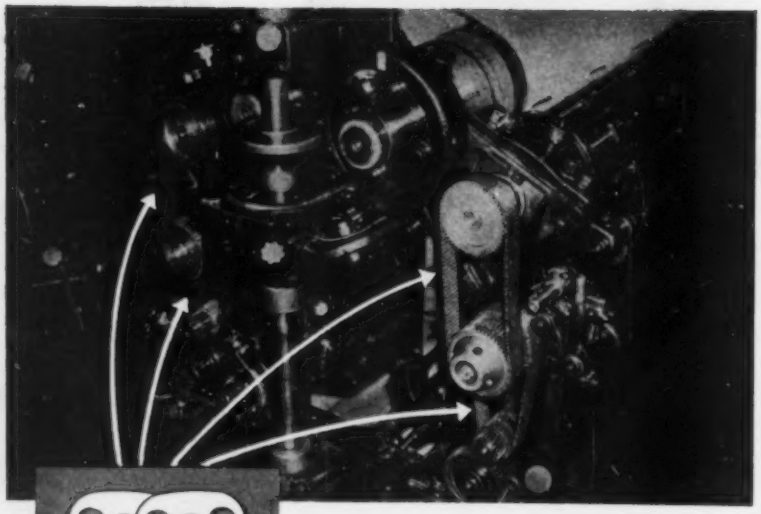


4. ***Assign to each unit ALDEN SENSING ELEMENTS — to spot trouble instantly!***

Compact front panel easily mounts 6 tiny Alden Sensing Elements — specifically designed to lick the problem of small space.
MINIATURE TEST JACK
MINIATURE INDICATING LIGHT
MINIATURE INDICATING FUSE HOLDER

By thinking of your Electronic Controls in terms of ultimate plug-in units – you lick the problem of RELIABILITY IN SERVICE for your Customer . . . and you wash out problems of Design, Manufacture and Procurement for all concerned.

NA-ALO **ALDEN PRODUCTS CO.** 135 N. Main St., Brockton 64, Mass.



• THE UNIQUE, FRICTIONLESS RAMSEY JOINT enables the chain to flow over the sprocket as smoothly as water flows over a dam. Note in the picture above how the contact surfaces of the pins roll on each other. Ramsey Chains take no toll of the power they transmit.

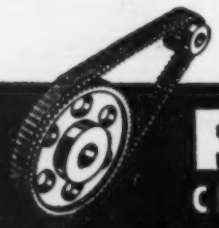
For increased production, quietness, efficiency

RAMSEY SILENT CHAIN DRIVE

There is no other chain like the Ramsey—no other chain with the roller-bearing pins between links, eliminating friction and permitting of the fullest flexibility no matter what the load and speed. You get quietness too, which is a positive indication of non-friction. You get a cool-running, uniform flow of power, needing no oil pumps or slingers, mighty little lubrication, and practically no maintenance, and the long service life that results only from the absence of wearing friction.

FREE APPLICATION MANUAL FOR ENGINEERS

This 60 page book gives you the range and scope of Ramsey Silent Chain Drives—tells you how to work out applications and includes the necessary data on chains, sprockets and pinions. Write for a copy today.



SILENT CHAIN DRIVES – FLEXIBLE COUPLINGS

RAMSEY
CHAIN COMPANY, INC.
5150 BROADWAY • ALBANY, N. Y.

HOW TO PLAN PRODUCT COLORS

8 pages—20 cents a copy

Howard Ketcham, well-known industrial designer, has developed color and design themes for over 500 products and packaged items ranging from household appliances to locomotives. In this *Product Engineering* report he discusses the principal factors involved in matching color with product function, sales and advertising appeal, maintenance considerations, worker efficiency, safety, and size effect.

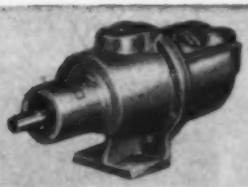
Copies of other reports in *Product Engineering's* series of full-color articles covering product improvement through better surface appearance and protection are also available. Write for an editorial reprint order form, listing titles and costs.

READER SERVICE DEPARTMENT

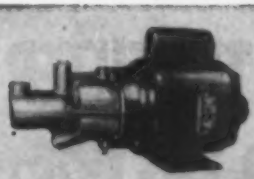
Product Engineering

McGraw-Hill Building, New York 36, N. Y.

Moyno designed for pumping ethylene glycol, condensate from automatic driers, hot and cold water in dishwashers.

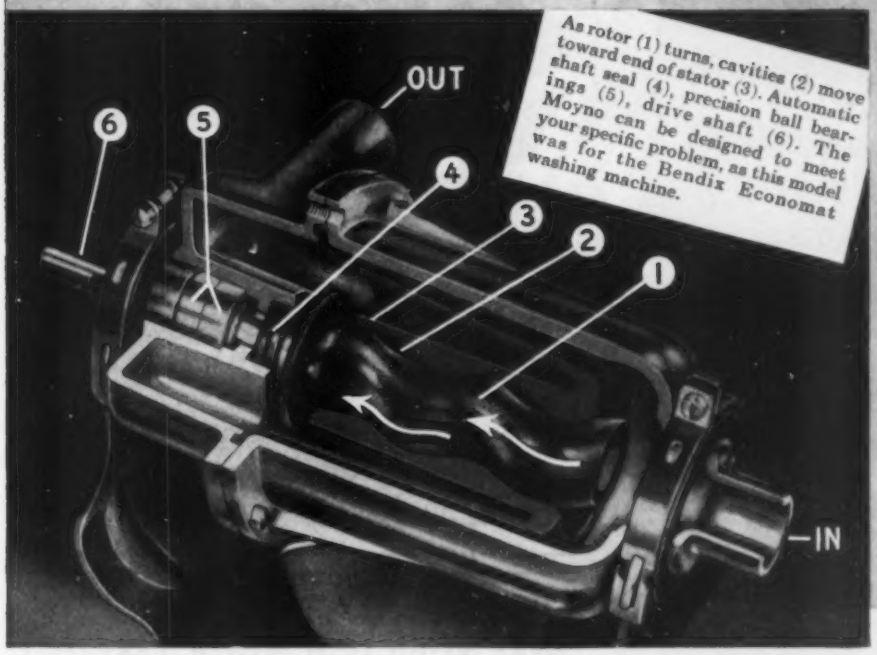


General purpose Moyno for pumping oils, water, alcohols and caustics.



Bronze and stainless steel Moyno as used in a drink dispenser. Pumps water at more than 100 p.s.i.g.

Here's a compact version of a low head, small displacement Moyno for accurate pumping of small amounts.



As rotor (1) turns, cavities (2) move toward end of stator (3). Automatic shaft seal (4), precision ball bearings (5), drive shaft (6). The Moyno can be designed to meet your specific problem, as this model was for the Bendix Economat washing machine.

Versions of this compact Moyno are applicable as coolant pumps, shallow well pumps and booster pumps.

Economical Moyno for the appliance field, designed for use under flooded head.

BEFORE YOU "FREEZE" YOUR PRODUCT DESIGNS...

Read these FACTS *about* MOYNO® PUMPS!

One of these characteristics may improve YOUR product!

Versatile—Pumps liquids, pastes, abrasive-laden slurries. Adaptable to heavy industrial machinery or small drink dispensers, oil burners, dishwashers, sprayers, coolant pumps, etc.

Positive Displacement—Moynos are available to pull up to 29" of vacuum while discharging under pressure. Big Moynos can deliver up to 250 gpm. Pressures to 600 psi obtainable. Provide controllable, non-pulsating flow for metering purposes, in either direction!

Gentle—No churning, foaming; won't break up semi-solids. One Moyno is pumping potato salad!

Trouble-Free—Self-priming; won't cavitate or vapor-lock. Just one moving part—no valves to stick, no pistons to gum up. Low starting and running torque.

What you see here are seven variations of a *completely different concept of pump design* . . . the R&M "Moyno" Pump. It operates on a unique progressing-cavity principle, as shown by the large cutaway.

But even more important than how it works is how it *performs*. A good example is the Bendix Economat Washer, on which Moyno Pumps last *seven and a half times longer* than any pump tried before! On other types of applications—pumping everything from water, air, and abrasive-laden liquids to heavy, non-pourable pastes—users find that the simple Moyno Pump design saves maintenance dollars!

If you use pumps—and particularly if your pumping application is a little different—*there's a strong possibility that the Moyno can add new features to your product.*

New Bulletin No. 50 has more facts

Contains performance curves and details on pumping characteristics. Write for your free copy. If you can describe your application, we will be able to reply in even more detail. PD-113

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Fractional & Integral h.p. Motors & Generators

Electric Fans

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Moyno Pumps

Propellair Industrial Ventilating Equipment

The SIMPLER THE FILTER THE LOWER THE COST

Specify **Bendix-Skinner** RIBBON FILTER ELEMENTS . . .

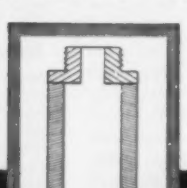
- LOWER ORIGINAL COST
- SIMPLE, INEXPENSIVE TO INSTALL
- NO EXPENSIVE BACK UP SUPPORT REQUIRED
- PERMANENT TYPE
- HIGH FLOW RATE (EITHER DIRECTION)
- EASILY CLEANED

It seems hard to believe, but you can actually have more efficient filtration at considerably lower cost if you simply use Bendix-Skinner ribbon elements instead of expensive and less adaptable metal edge or metal screen types.

Here's how it works—Bendix-Skinner ribbon elements are inexpensive to begin with and can be installed at far less cost than metallic elements that require special back-up supports. In fact, in practically every instance present metallic-type elements can be changed over to ribbon-type with substantial savings.

Ribbon units are available in diameters from ½" to 6" in any required length with filtration rated at 40 microns (.0016").

Our engineering department will be glad to advise on new installations or to furnish replacement units in a variety of sizes. Write us for details.



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IN SMALL QUANTITIES

FUNK production facilities enable you to buy only the quantities you need of Gear Reduction Power Take-Offs in special ratios and special adaptions of standard units. Prompt delivery of special units, immediate delivery of standard models.

EXCLUSIVE STRADDLE MOUNTED PINION

This exclusive Funk development assures complete gear tooth contact at all times by providing a pinion with a taper roller bearing support at each end driven by an input shaft with a lubricated floating spline, eliminating misalignment from improper installation or load deflection.

Funk

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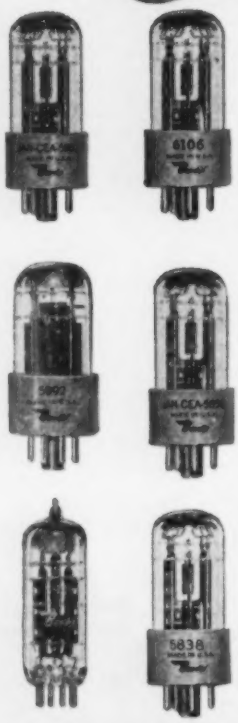

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With electronic controls taking over more and more operational functions in aircraft, it's becoming increasingly important that the electron tubes used be dependable under conditions of high altitude, continuous vibration, varying voltages and frequent shock. Because of their advanced design and construction . . . born of never-ceasing research and special production skills . . . Bendix Red Bank Reliable Electron Tubes have the dependability necessary to meet these severe operating conditions. You can depend on our long, specialized experience to give you the right answer . . . for all types of regular as well as special-purpose tube applications. Call on us for full details.

Manufacturers of Special-Purpose Electron Tubes, Inverters, Dynamotors and Fractional D. C. Motors

TYPE AND MODEL INDEX				TYPICAL OPERATING CONDITIONS		
Bendix No.	RTMA No.	JAN No.	General Type	Heater Voltage	Plate Voltage Per Plate	M.A. Load
TE-2		5839	OCTAL FULL WAVE RECTIFIER	26.5	350	70
TE-3	5838		OCTAL FULL WAVE RECTIFIER	12.6	350	70
TE-5		5852	OCTAL FULL WAVE RECTIFIER	6.3	350	70
TE-10	5993		MINIATURE FULL WAVE RECTIFIER	6.3	350	70
TE-22	6106		OCTAL FULL WAVE RECTIFIER	5.0	350	100

BEAM POWER AMPLIFIER TUBE	
SPECIFICATIONS	
BENDIX NO.	TE-8
RTMA NO.	5992
HEATER VOLTAGE	6.3 V
PLATE VOLTAGE	250 V
SCREEN VOLTAGE	250 V
GRID VOLTAGE	12.5 V
G. M.	4000
PLATE CURRENT	45 MA
POWER OUTPUT	3.5W

Manufacturers of Special-Purpose Electron Tubes, Inverters, Dynamotors and Fractional HP D. C. Motors

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In line with the rising use of porcelain enamel coatings for a steadily increasing variety of products, there are now hundreds of formulations available for many different property requirements . . . in practically any color you may want.

This Special Editorial Report contains invaluable information on types of porcelain enamel coatings, application methods, properties, and base-metal design factors. It is one of *Product Engineering's* brilliant series of full-color reports on product improvement through better surface appearance and protection.

Copies of other reports in this series are also available.

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McGraw-Hill Building, New York 36, N. Y.

There is Still Time to Win a Fine Camera

Enter the Peerless Photocopy-in-Industry Contest

Only One Month Left. Complete Set of Prizes Will be Awarded

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Contessa 35 Tessar f/2.8, retail price $216.00
Ikoflex IIa Tessar f/3.5, retail price $216.00

2nd PRIZE Contina I Tessar f/2.8, retail price $119.00
Your choice of: Ikoflex Ia Novar f/3.5, retail price $125.00

3rd PRIZE Nettar IIc Novar f/6.3, retail price $41.70

1st Prize—Contessa 35
An outstanding 35 mm camera with 45 mm Zeiss Opton coated Tessar f/2.8 lens. Automatically focused by a built-in combined view- and range-finder. Has built-in photo-electric exposure meter. Synchro Compur shutter is fully synchronized. Speeds from 1 to 1/500 sec.

1st Prize—Ikoflex IIa
A truly fine reflex camera with Zeiss Opton coated Tessar f/3.5 lens, in Synchro Compur fully synchronized shutter. Speeds from 1 to 1/500 sec.

The cameras listed above will be sent to the winners of this contest at absolutely no cost. All cameras come complete with top-grain leather carrying cases. All carrying charges prepaid.

HERE'S HOW YOU CAN WIN

The contest is open to everyone actively interested in industrial photocopy.

Write a report on one of the photocopy applications or photocopy techniques that you find most valuable in your business. There is no limit to the length of your report. It can be supplemented with examples of the result achieved, sketches of the process, anything which you feel will lead to a full appreciation of your use of photocopy. Although originality is important, the significance of the result achieved will determine the winners.

Example: Suppose you use photocopy to eliminate certain drafting steps such as the redrawing of an entire part in order to make a simple change. Tell in your report exactly what steps you take to get the desired result. Tell also what this means to your drafting department in terms of time saved. Name the paper and machines involved in your process, and tell why you use them. Remember, the more complete and understandable your report, the better your chance to win.

ONLY ONE MONTH LEFT!

To qualify for this month's awards, entries must be postmarked no later than December 10, 1953.

THE JUDGES

The contest will be judged by the executive board of Industrial Photography magazine: Ben Zale, Editor; Lloyd E. Varden, Scientific-Technical Editor; David B. Eisendrath, Jr., Technical Editor. The winners will be reported shortly after the closing date.

YOUR REPORT IS A VALUABLE CONTRIBUTION TO THE INDUSTRY

We are planning to publish the winning reports as a portfolio of modern photocopy practices. The purpose of this portfolio will be to show how valuable photocopy is as an industrial tool, and as evidence of what is being done by experts in the field. No report will be published in the portfolio, or used in any other advertising or promotional material without your written permission and that of the company involved.

PEERLESS PRODUCTS

Peerless is one major manufacturer in the field whose production and development facilities are devoted exclusively to industrial, scientific and commercial photo-reproduction. The entire Peerless line of photocopy papers and machines is sold only through a network of factory distributors who are skilled photocopy specialists. Complete literature on all Peerless products is yours for the asking.

DON'T DELAY! Send your report to:

PEERLESS PHOTO PRODUCTS, INC.

Shoreham, Long Island, N.Y.

Manufacturers of Quality Photocopy Papers and Special-purpose Industrial Photocopy Equipment

Dependable performance for aircraft sprayers . . . with

STOW flexible shafting!

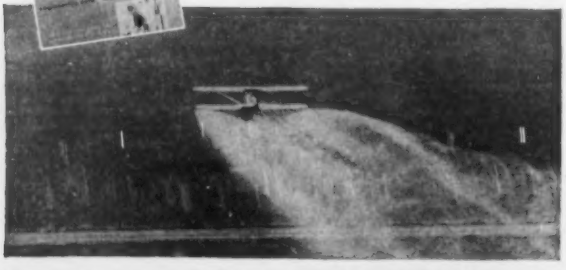
It's important in crop spraying to get thorough coverage of the crop. That calls for reliable equipment like the Aero Mist Master which depends on STOW flexible shafting to transmit power from the accessory gear box to the pump which delivers the insecticide to the spray nozzles beneath the wing.

According to Mabry I. Anderson, of Mississippi Valley Aircraft Service, manufacturers of the Aero Mist Spray System, "Your shafts have never failed—even though they've already given us thousands of hours of *trouble free* service".

Consider STOW flexible shafting for your next Power Drive or Remote Control application. Our engineering department will be happy to work with you. No obligation, of course.

◀ ***Write today*** for your free copy of Bulletin 525 containing complete engineering data on STOW flexible shafting.

See us in SWEET'S CATALOG



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MINIATURE PRECISION HYDRAULIC VALVE

Skinner's new V10 Series Miniature Hydraulic Valve is an amazingly compact unit, capable of handling pressures up to 1000 P.S.I.

This precision-made valve is ideally fitted for use in the automatic operation of single and double acting hydraulic cylinders, and in pilot control of larger three and four way hydraulic valves.

The V10's construction is consistent with the Skinner quality tradition: most internal parts are of stainless steel; the slide mechanism has a precision-ground piston, and a bore honed to extremely close tolerance, thus minimizing leakage.

Specifications: 1/8" NPT threaded ports; effective orifice diameter of 3/32"; available in the full range of AC and DC voltages.

The economical design and unusually small size of the Skinner Miniature Hydraulic V10 valve will enable many manufacturers to install it in places where, heretofore, remote control devices have been considered impractical.

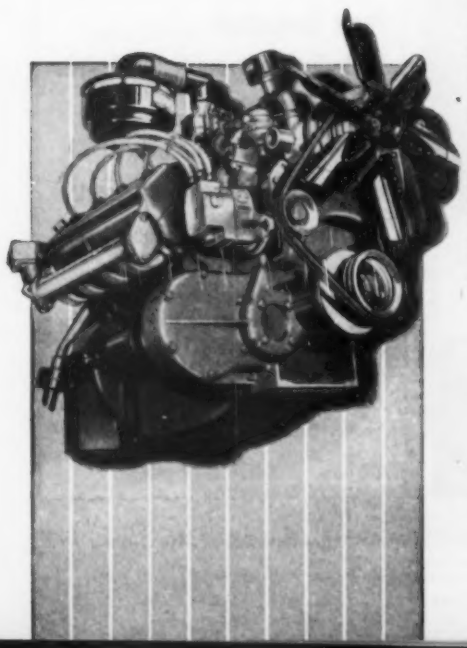
SKINNER ELECTRIC VALVES

Skinner ELECTRIC VALVE DIV.

THE SKINNER CHUCK COMPANY
114 Edgewood Ave., New Britain, Conn.

Photo courtesy Hale Fire Pump Company, Conshohocken, Pa.

Chrysler Power provides modern solution to age-old problem of irrigation



Early last summer, the owner of this 640-acre farm near Williamsburg, Virginia, decided to irrigate 120 acres. Taking his water from the nearby James River, he irrigated 70 acres of corn, 50 acres of soy beans. Water was pumped at the rate of 960 gallons per minute, fourteen hours a day, seven days a week. Each acre required approximately 36,000 gallons.

The results were astounding. Not only did this farmer save his crops during an especially dry summer, but his corn and soy bean yields actually *increased* 100% over the year before. In each case, 1952 was considered a normal year.

What this farmer did with his Hale Model CIRV Pump demonstrates again the effectiveness of Chrysler Power. Here the 331-cubic-inch displacement Model 20 V-8 Engine is used because the manufacturer wants great power with light weight, continuous, economical operation.

Manufacturers find Chrysler Engines ideal for almost any equipment requiring extra power without extra weight. Manufacturers also find they can order engines equipped *by Chrysler* to meet the needs of the equipment and their customers. For example, Chrysler Engines can be supplied with gasoline, natural or liquid propane gas burning carburetors, standard or gear-driven front ends, 12 or 24 volt electrical system.

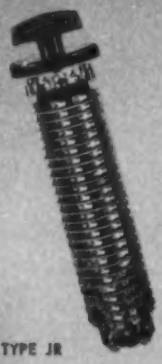
Chrysler Industrial Engines are not expensive. Production line methods, adapted to specialized industrial engine building, provide a custom-built engine at mass-production prices. See a Chrysler Industrial Engine Dealer, or write: ***Dept. 411, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

CHRYSLER
Industrial Engines

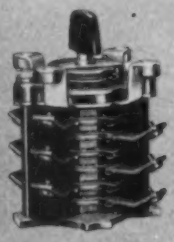
HORSEPOWER **WITH A PEDIGREE**

ROTARY SWITCHES

For every control, tap, and transfer application.



TYPE JR



TYPE P, 30A

TYPE A

TANDEM TYPE P, 30-10A

TYPE HF

- Save valuable panel space
- Simplify control of complex circuits
- Give "dead-front" mounting safety
- Listed by Underwriters Labs, Inc.
- Can be furnished to latest Navy specs.
- Ratings from 2 amperes to 200 amperes, 30 to 250 volts d. c., and 125 to 500 volts a. c. — depending on number of circuits and nature of load.

Write for combined catalog giving useful design data on Esco rotary switches.

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CORPORATION
167 King Avenue, Weymouth 88, Mass.

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Every November, you will add a new HANDBOOK of Product Design to your reference library. The HANDBOOK is part of your regular subscription to *Product Engineering*.

How to Mold a TV Star

This "pop-up" bandshell speaker is the latest in a long line of new electronic developments which we have molded for Zenith. It is designed to bring console range of tone to table model TV sets. Oddly enough, in order to meet demands of both quality and economy the speaker had to be molded the hard way—all in one piece. This one piece molding eliminated tonal vibration in the speaker and also did away with complicated, costly problems in assembly. Economy and speed of production

Bandshell Speaker and Control Panel Door, Molded for Zenith Radio Corp., Chicago

were further helped by our design which eliminated any "side-pull mechanism". The control panel door, while of a more conventional nature, was still designed in a way to cut costs in production and assembly by having the screw holes pulled right in the mold. We believe we can show you how to make the skillful use of plastics play a similarly starring role in your product's sales picture. May we audition for you without obligation soon?

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about [redacted], piping, tubing and fittings, write for circulars containing data and illustrations.*

*Trade Mark Reg.

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a subsidiary of

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INJECTION MOLDED and EXTRUDED Thermo-Plastic Materials Including Cellulose Acetate, Cellulose Acetate Butyrate, Acrylates, Methacrylates, Styrenes, Vinyls, Vinylidene Chloride, [redacted]*

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NEW HIGH-LOAD BEARINGS

JOHNSON ALUMINUM-ON-STEEL SLEEVE BEARINGS

THE TREND in much industrial equipment design is to higher loads at higher speeds. In step with this, Johnson Bronze has developed an entirely new bearing metal, alumium-on-steel, with higher strength, higher load capacity, and resistance to high temperatures. Already these bearings have been hailed by the diesel industry, where these special properties are greatly needed. These roll-bonded Johnson Aluminum-on-Steel Bearings may be used for loads up to 5,000 P.S.I., yet have good conformability, good resistance to shaft wear, good corrosion resistance, adequate seizure resistance and good resistance to fatigue. Tests prove that the bond to the steel back is as strong as the metal itself. You may find it advantageous to incorporate them in your new plans. Write today for complete information.

JOHNSON BRONZE COMPANY
508 South Mill Street, New Castle, Pennsylvania

JOHNSON BRONZE PRODUCES ALL TYPES OF SLEEVE BEARINGS:

BRONZE-ON-STEEL, copper lead • STEEL BACK, babbitt lined • BRONZE BACK, babbitt lined • CAST BRONZE, plain or graphited • SHEET BRONZE, plain or graphited • CAST ALUMINUM ALLOY • ALUMINUM-ON-STEEL • LEDALOYL powder metallurgy

SLEEVE BEARING HEADQUARTERS SINCE 1901

JOHNSON JB BEARINGS
Sleeve-Type

Four different types of synchronous motor driven INTERVAL TIMERS

the answer to most interval timing-control problems

MANUAL SET TIMERS • Series RS

Compact, rugged construction handles high load without auxiliary relay. Heavy-duty, snap-action contacts maintain continuous pressure and wiping action. 18" color-coded leads facilitate wire connections. 20-amp. rating – completely enclosed – 2½" dia., 3½" length – easy-setting knob – elapsed-time indication. Time-cycle ranges, 15 min. to 12 hrs., dial calibration, 15 sec. to 15 min. 115-volt AC current, 60, 50, or 25 cycles. *Complete information in Bulletin #59*

INSTANTANEOUS RESET TIMERS • Series PAB

For process control in industry. Have automatic reset, time-setting adjustment, large numerals. Extremely accurate. Built to stand hard usage. Timing range 1/10 sec. to 5 sec. in 1/10-sec. steps (PAB-3S)– to 2 min. to 3 hrs. in 2-min. steps (PAB-3H). *Complete information in Bulletin #58*

AUTOMATIC RESET TIMERS • Series P and M

Series P have AC input line cord, built-in actuating start button, receptacles for plug-in remote-control and load circuits. Time cycle, 15-sec. to 5-min., dial calibration, ¼ sec. to 5 sec. 115 or 220 volt AC, 50 or 60 cycles.

Series M is similar to Series P, but start button cannot operate from remote position. Receptacle for plug-in load circuit. 60-sec. time cycle, calibrated in seconds. *Complete information in Bulletin #68*

SIGNALING TIMERS • Series S

Command eye and ear attention when time interval is completed. Automatically closes or opens circuit at end of elapsed time, and operates buzzers, bells, or lights at remote stations. 5"x5"x3", readily attached to wall, panel, or switch box. 115 to 230 volts AC, 25, 50, or 60 cycles. Slow-speed, self-starting motor. Pure silver contacts. Interval range, 1 min. to 3 hrs., dial calibrated, 1 sec. to 5 min. *Complete information in Bulletin #98*

Manufacturers of these and other timers and controls for Industry: AUTOMATIC RE-CYCLING TIMERS • TIME-DELAY TIMERS • RUNNING TIME METERS • INTERVAL TIMERS.

Timers that Control the Pulse Beat of Industry

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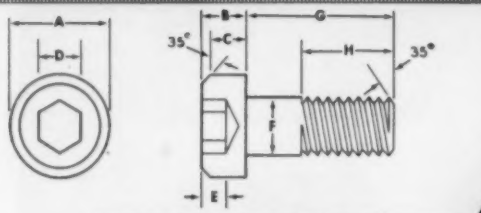
DESIGN ENGINEERING at YOUR Service..



MAC-IT PARTS COMPANY							
MATERIAL SAE 4140 STEEL ALLOY- ROCKWELL							
FINISH CHROMIUM PLATING ON STEEL G.M. 4251-							
TOLERANCE IN LENGTH THE TOLERANCE IN LENGTH							
A	B	C	D	E	F	G	H
1/8	244	229	185	127	248	5/8	1/8

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Mac-it socket-head screws, providing strength without bulk, give lighter weight, streamlining, and more secure fastening to equipment you design. Whether the design problem involves standard or special screws, Mac-it will add to the appearance, efficiency and performance of the equipment. Use Mac-it Fastener Engineering Service for all problems involving screws for any type application.

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The precision manufacture and quality control used in making Mac-it Screws provide users with high dimensional accuracy and uniformity. All Mac-it Screws in both coarse and fine threads are held to a class-3 fit. Mac-it maintains a Fastener Engineering Service for the design, development and production of screws for all types of applications.

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Manufactured by Mac-it Parts Co., Lancaster, Pa.

Contact your nearest Mac-it distributor or the Home Office, Cleveland, Ohio, for the Mac-it Catalog No. 49 which contains full technical data.

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For use in Neon Sign Transformers, one piece fits inside transformer case, other piece fits outside case, forming a perfect insulator.

• Porcelain Insulators, properly engineered and applied, add high dielectric and physical strength. In Universal Porcelain Insulators, you gain this extra protection . . . *plus* higher resistance to temperature changes, moisture, fumes and most acids. On your next insulator job, specify Universal Porcelain.

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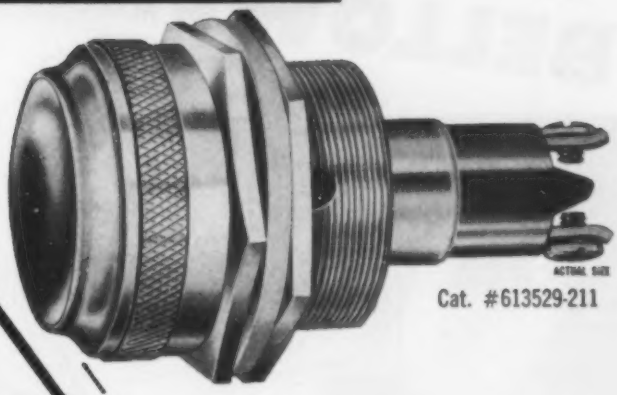
WHICH PILOT LIGHT DO YOU NEED?

DIALCO

THE BIG ONE

This Pilot Light Assembly was first made to accommodate the *S-11 lamp* and was intended for use in the cabs of great diesel locomotives.



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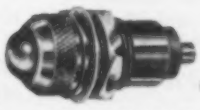
This BIG one

or

this LITTLE one

THE LITTLE ONE

The miniaturization program on defense products required the development of this *sub-miniature* light. It is used on communication equipment and aircraft. Midget flanged base bulbs to fit are rated 1.3, 6, 12, and 28 volts.



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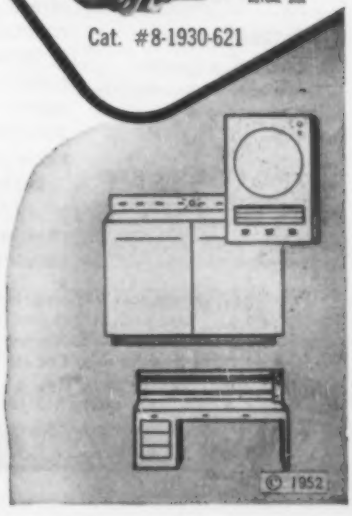
Samples to suit your own special conditions and requirements will be sent promptly and *without cost.* Just outline your needs. Let our engineering department assist in selecting the *right lamp* and the *best pilot light* for YOU.



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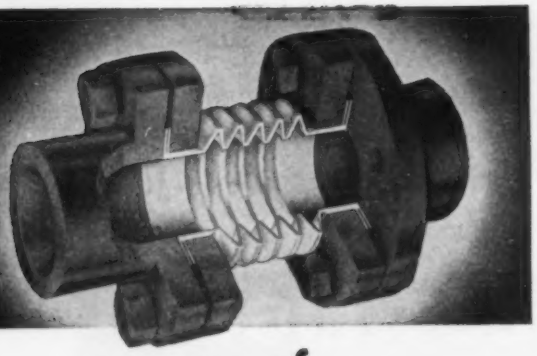
NOW... *to handle those difficult piping problems*



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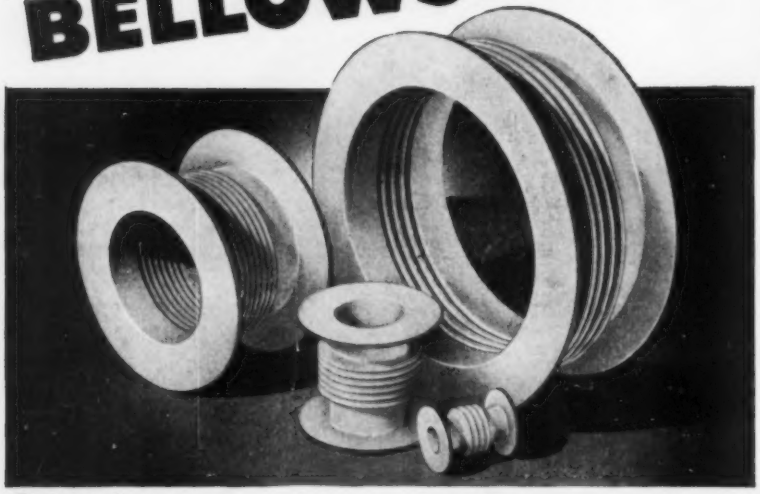

1. **Chemically inert** —*will handle all corrosive liquids, petroleum products, gases and solvents.*
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Made from a special densely molded stock and so machined that there is no inherent stress at their free length—*they expand and contract in either direction with equal freedom of motion.* End flanges of French-type gasket construction facilitate easy assembly and assure a leak-proof seal. Stock sizes are available in a full range of standard pipe dimensions from 1 to 8 in.

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Further information on Teflon parts and products, including bellows connectors, pump and valve packings, tubing and other molded forms, is available in "John Crane's" 12-page illustrated catalog, The Best in Teflon. *Send now for your free copy. Crane Packing Company, 1345 Cuyler Avenue, Chicago 13, Illinois.*

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True it's something of a record when 7 parts are combined to make 1 . . . eliminating all except 1 reaming operation.

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The illustrated cam originally required 7 parts, individually machined out of cold rolled steel, and then assembled by brazing.

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1) Shaft — turned, drilled, faced and slotted from bar stock
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PARTS . . . Single Casting
FINISHING . . . Ream Shaft & Heat Treat
EST. SAVINGS . . . Tools 60%, Finished Part 40%

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Let our engineers show you how to apply the precision casting process in your industry, so your company can also realize substantial savings in money and production time. Drop us a line and we will have one of our sales engineers call on you.

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If you would like further information about the process before requesting our representative, write for our booklet, "Alloy Selection and Design for Investment Castings." We also recommend the book *"Investment Castings for Engineers", published by Reinhold Publishing Corp.*

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Plasticskills Coordinated with Precision Assembling

Curtis Build-Up Terminal Block Kit

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TERMINAL BLOCKS using Triple "M" Phenolic Plastics
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Triple "M" Knows Plastics for Electrical Functions

. . . and in helping Curtis produce better Terminal Blocks MMM meets rigid requirements for Insulating Properties, Dielectric Strength, Impact Resistance, Dimensional Stability, and Uniformity. This ability to meet Performance, Quality, and Delivery "Musts" is an asset to manufacturers using Triple "M" Molded Electrical Components. We'd like to discuss YOUR component needs. Use the coupon; no obligation.

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Why use a high starting torque motor? *We guarantee* that a general purpose electric motor *plus a Mercury Clutch* will give almost any equipment greater efficiency.

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The Mercury Clutch

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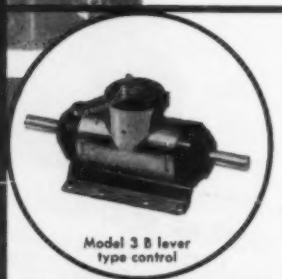
Design Simplified...

with the Metron VARIABLE SPEED DRIVE

- Permanently lubricated
- Your choice of 6 controls
- Speeds up to 10,000 RPM
- Nominal output .025 HP

• For further information about how Metron units can simplify your costly speed changing problems, write for Bulletin 99.

Metron



Model 3 B lever type control

Design engineers at Century Geophysical Corporation make use of the Metron Variable Speed Changer to give them continuously adjustable chart speeds in their miniature oscillograph.

Century engineers find that it is simpler and more economical to use Metron Miniature units as components than to design and build their own.

Metron Variable Speed Changers are designed into countless products that call for changes in speed. The units are small—only 4 3/16" long—to fit minimum space. They are smooth and accurate in operation and cover infinitely variable output speeds from 5:1 step down thru 1:1 to 1:5 step up.

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Complete stocks in a wide range of sizes assure you prompt delivery.

The H. M. Harper Company has specialized for almost a third of a century in fastenings of non-ferrous metals and all stainless steels, and is the largest manufacturer in this field. Over 7,000 items are available from stock in aluminum, brass, naval bronze, silicon bronze, Monel and all stainless steels.

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Company.....*Position*.....

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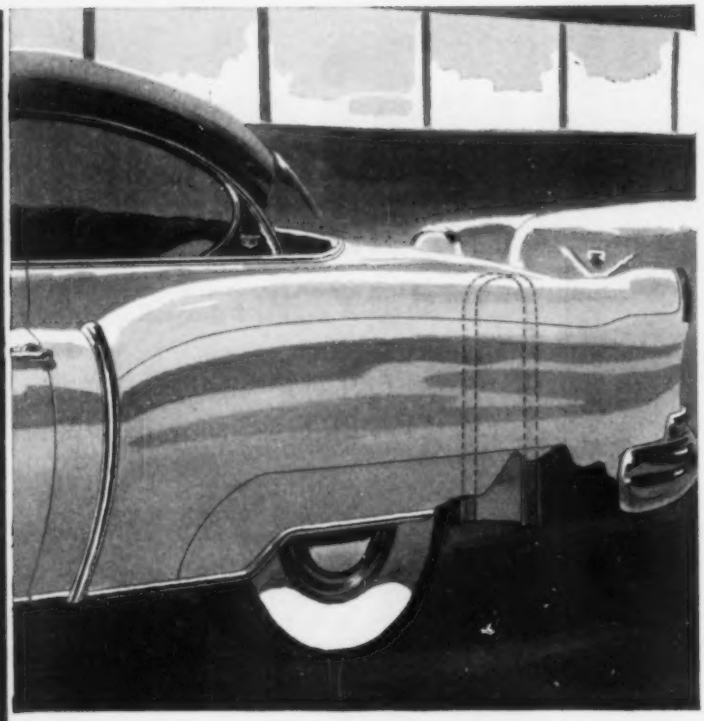


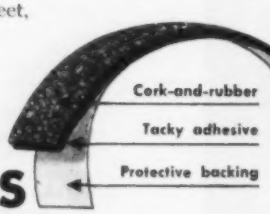
This cork-and-rubber tape stops auto fender squeaks

To eliminate fender squeaks and rattles, this auto manufacturer puts a strip of Armstrong's DK-153 Cork-and-Rubber Tape between the rear fender and the splash pan.

Held firmly in place by its own pressure-sensitive adhesive, DK-153 does more than just prevent contact between the two metal surfaces. The tape's high-friction surface, dotted with cork particles, actually snubs the sliding itself.

DK-153 Tape has hundreds of other uses. It protects finely machined or breakable parts from shipping damage, keeps telephones and furniture from skidding on polished surfaces, keeps water out of bus windows and parking meters, among other things.

You can get Armstrong's DK-153 Tape in many different widths and thicknesses, in sheets, rolls, ribbons, and die-cut shapes. For samples, write on your letterhead to Armstrong Cork Company, Industrial Division, 7311 Irvin Street, Lancaster, Penna. Available for export.



ARMSTRONG'S DK-153 TAPE

How to
Plan and Control Production
—for greater speed and efficiency

This guide brings you tested and improved methods of routing, scheduling, dispatching, inspecting, following-up.

PRODUCTION CONTROL

By L. L. Bethel, W. L. Tann, F. S. Atwater and E. E. Rung

Second Edition, 284 pp., illustrated, $4.00

You can get greater volume at lower cost with these successful methods of production planning and control. This guide book helps you handle more effectively your everyday problems of routing, scheduling, dispatching, inspecting, and following-up. Based on practical experience, it reflects current factory methods in more than 185 representative companies in all types of industries.

It brings you the principles behind improved control systems . . . hundreds of techniques and actual industrial cases. Operation analysis—budgeting costs—preparing a master schedule—translating orders into production—following-up — inspection — record keeping — these and scores of other planning and control methods are analyzed and evaluated.

Gives you up-to-the-minute guidance on:

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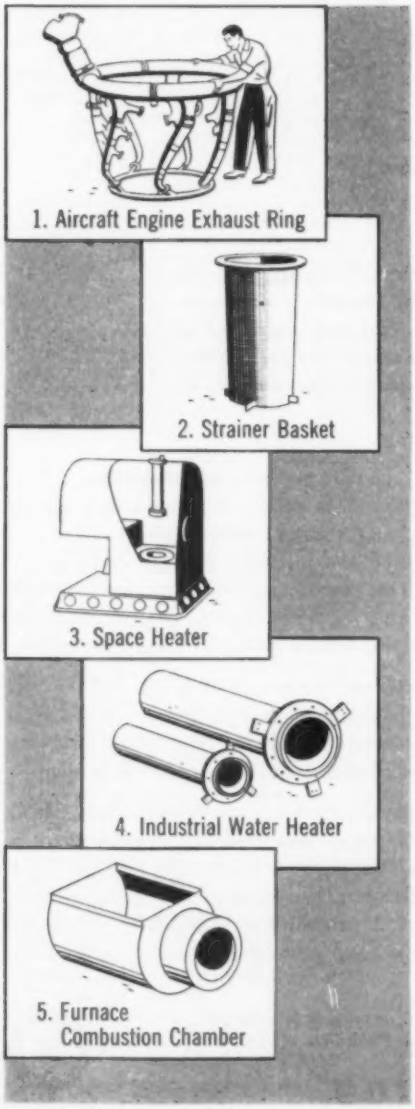
to combat

HIGH TEMPERATURES



Temperatures of 1700° F and even higher are within the working range of recently-developed Porcelain Enamels and Ceramic Coatings. Coupled with excellent corrosion resistance, the ability to withstand high temperatures makes Porcelain Enamel an exceedingly valuable finish for a wide variety of applications. In many high-temperature applications, Porcelain Enamel's resistance to thermal shock, and its exceptionally high emissivity value are very important advantages.

Porcelain Enamel is formed by fusing a glass-like coating to a metal base when it is above the "red-hot" temperature. This inseparably bonds the coating to the metal. Therefore Porcelain Enamel combines the strength of the metal and the hard, non-porous, impervious characteristics of glass. Being entirely inorganic, it is appropriately called "The Lifetime Finish."

Parts are readily produced in a wide variety of sizes and shapes. Base metals include many carbon and alloy steels, cast iron and non-ferrous metals. Fabrication of the metal is by customary methods. The enameling may be done by firms who specialize in this work.

Use the coupon below to get information that will help you design with this modern engineering material.

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Will you please send me your latest design information on Porcelain Enamel. I am interested in this material for:

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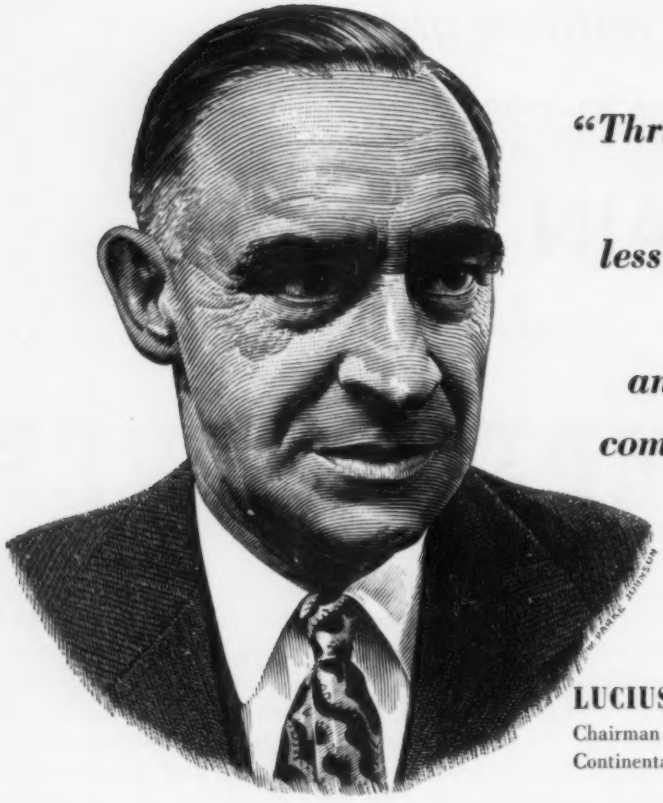

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LUCIUS D. CLAY
Chairman of the Board
Continental Can Company

"The regular purchase of Savings Bonds through the Payroll Savings Plan by millions of our citizens contributes importantly to the country's economic stability, the national defense effort, and to the financial independence of the individual. The thrifty, self-reliant citizen is one far less likely to be taken in by the false promises and ideologies which communist propagandists invariably direct to the 'have nots'."

• To thousands of company executives, accountants, payroll department employees, PSP means Payroll Savings Plan, the simple payroll allotment operation through which employees make a monthly investment in U. S. Savings Bonds.

• To almost eight million employees of nearly 50,000 companies, PSP has a more intimate connotation. To them, PSP spells *Personal Security Plan.*

• Multiply the personal security of a single Payroll Saver by 43,000,000—the number of individuals who hold Savings Bonds having a cash value of $49.5 billion—and you have economic stability that is the keystone of our national defense.

• Thanks to the thousands of companies which offer their employees the Payroll Savings Plan, Bill Brown in the Machine Shop . . . Joe Green in the boiler room . . . and eight million more Browns and Greens can well turn a deaf ear to ". . . the false promises and ideologies . . ." of communist propagandists. Bill can see his new home taking shape in his growing stack of Savings Bonds . . . Joe sees each bond another step toward a college education for little Joe . . . and the "Old Timer," who eats his lunch with Bill, talks of "sitting down pretty soon" because his Bonds will make a nice addition to his Social Security.

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• If employee participation in *your* Payroll Savings Plan is less than 50%—or if your company does not have a Payroll Savings Plan—get in touch with Savings Bond Division, U. S. Treasury Department, Washington Building, Washington, D. C. Learn how easy it is to help your country, your employees and your *company*—through the PSP.

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Product Engineering

Facts about *HELI-COIL* inserts you should know

What they are

Heli-Coil* screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: *Heli-Coil* inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with *Heli-Coil* inserts. Get better-than-original strength with no increase in screw size and no tell-tale signs of rework.

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads—then *Heli-Coil* inserts are wound into tapped holes by hand or power tools. Install in a few seconds, assure thread protection forever. Can be used in any metal wood or plastic.

No other method is so simple, effective and practical.

What they do for you

Heli-Coil inserts *save money* because they strengthen threads and make *fewer* smaller fastenings do the same holding job. They make *lighter* bosses and flanges practical and they *save weight* in two ways: (1) by permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. *Heli-Coil* inserts *protect* your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. *Heli-Coil* inserts improve the end product, cut rejects, salvage threading errors.

Best time to put *Heli-Coil* inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write today! Complete information and engineering data is available in the *Heli-Coil* catalog. Use Coupon!

*Reg. U.S. Pat. Off.

Approved for All Military and Industrial Uses

How to save headaches *in fastenings* 1-2-3

1

Lend an ear to the many successes with tapped threads where stripping, wear, cross-threading and corrosion used to occur.

2

Open your eyes to the surest way to end thread problems forever—*Heli-Coil** Screw Thread Inserts. This armored protection is simple to add—costs little—never fails.

3

Tell us about your products and we will show you how to add lasting protection against thread problems right on your production lines.

HELI-COIL **inserts** are precision formed stainless steel or phosphor bronze wire coils that add strength to screw threads in any material—especially in light metals and plastics. The result—an improved product—usually at *reduced* production cost.

Write now for FREE samples and complete technical data.

HELI-COIL CORPORATION

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THE PROBLEM

TO PROVIDE AN ADJUSTABLE DRIVE

The saw-sharpening machine shown below has a power-driven grinding wheel which has to be adjusted horizontally, vertically and angularly. The operation of the unit makes it necessary to mount the motor below the grinding wheel. When the designer wanted to find a way to drive the grinding wheel which would permit the necessary adjustments to be made, he picked

THE LOW-COST SOLUTION

AN S.S.WHITE POWER DRIVE FLEXIBLE SHAFT

The S.S.White flexible shaft provided a simple, inexpensive way to meet the requirements of the application. It not only saved parts, but allowed the grinding wheel to be set quickly and easily in any desirable operating position. If you are faced with a similar problem, you'll find S.S.White power drive flexible shafts a good way to simplify and save.

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We'll be glad to send you a copy of the 256-page flexible shaft handbook if you send us a request on your business letterhead. This handbook has all the information you need to select and apply flexible shafts.

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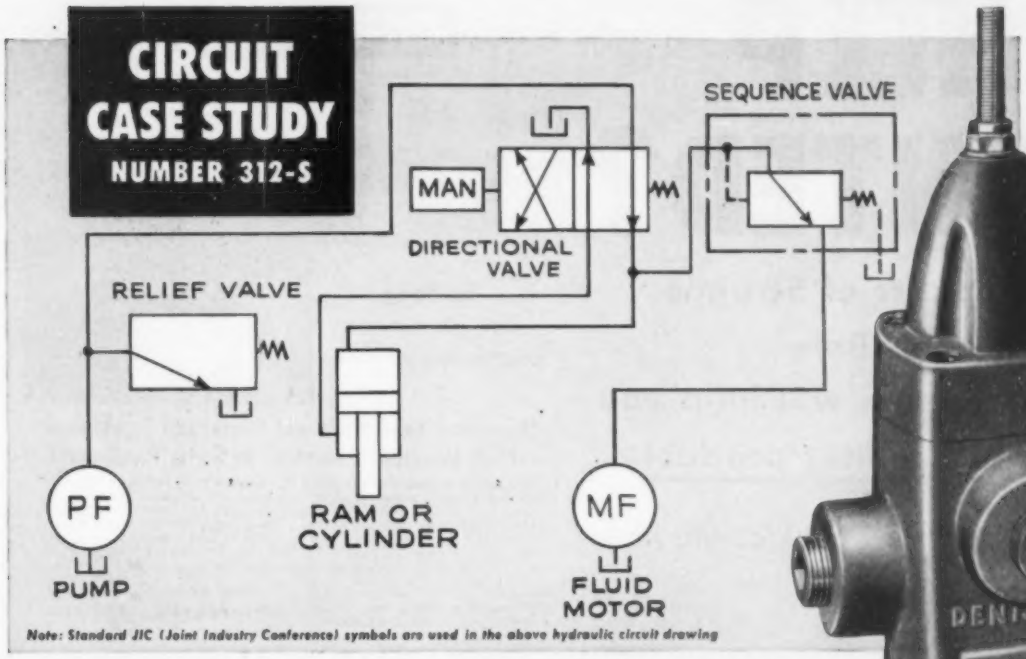

DENISON Sequence Valve

controls oil flow to secondary circuit with *quick, direct action*

Above, you see a typical circuit utilizing a Denison **Sequence Valve** of the direct-operating type. Here, oil pressure is developed by a fixed-displacement pump. When the manual control of the directional valve is held open, pressure is directed to a cylinder, which performs the primary operation. As the piston rod of the cylinder meets resistance, pressure increases. When the increasing pressure equals pressure setting of the **sequence valve** (which is easily adjusted to any operating need) it acts upon a small pilot piston in the **sequence valve**, shifting the valve spool. Oil flow is now open to both the cylinder and to secondary operation, performed in this case by a fluid motor. Additional sequence operations could be provided in similar manner.

Pressure build-up at the primary operation brings quick action on the spool of the **sequence valve**. The pilot piston, which eliminates the need for heavy spring loading of the valve spool in circuits operating at pressures above 250 psi, is not employed in models designed for lower pressures. Instead, pressure acts directly against the valve spool, assuring high sensitivity to low-pressure changes. These **sequence valves** are externally drained.

Denison direct-operating **sequence valves** provide positive action at relatively low cost, for circuit pressures from 25 to 2000 psi, and are readily adaptable to remote control arrangements. Denison also makes hydrostatically-operated **sequence valves** for pressures to 5000 psi.

Denison direct-operating pressure control valves are available in a wide range of models, for relief, unloading, counterbalance and sequence needs —with or without remote control and built-in checks. All are available in ½, ¾, 1 ¼, 1 ½ inch sizes, for all pressures to 2000 psi. Choice of threaded, subplate, or flange connections. We invite your inquiry on circuit needs of this type — or write for bulletin VRD.

Denison offers one of the most widely practical lines of oil hydraulic pumps, motors and controls for circuits operating at pressures up to 5000 psi. Designed and built with skill and knowledge gained through twenty-five years of engineering leadership in oil hydraulics, they offer the compact ruggedness needed for exacting, heavy-duty demands. Wherever you need closely adjustable power and control with unlimited flexibility of application, specify Denison HydrOILic Equipment. Your request for information will not obligate you in any way.

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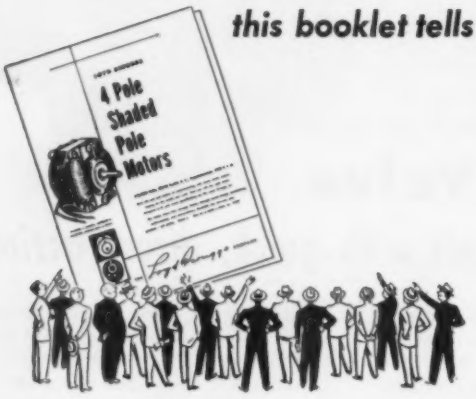
this booklet tells how



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Now you can start out with the *right* motor—a dependable *Scruggs Motor*—designed to fit your exact specifications. This service, which has been used in the development of a number of outstanding products, is described in a booklet which is yours free on request.

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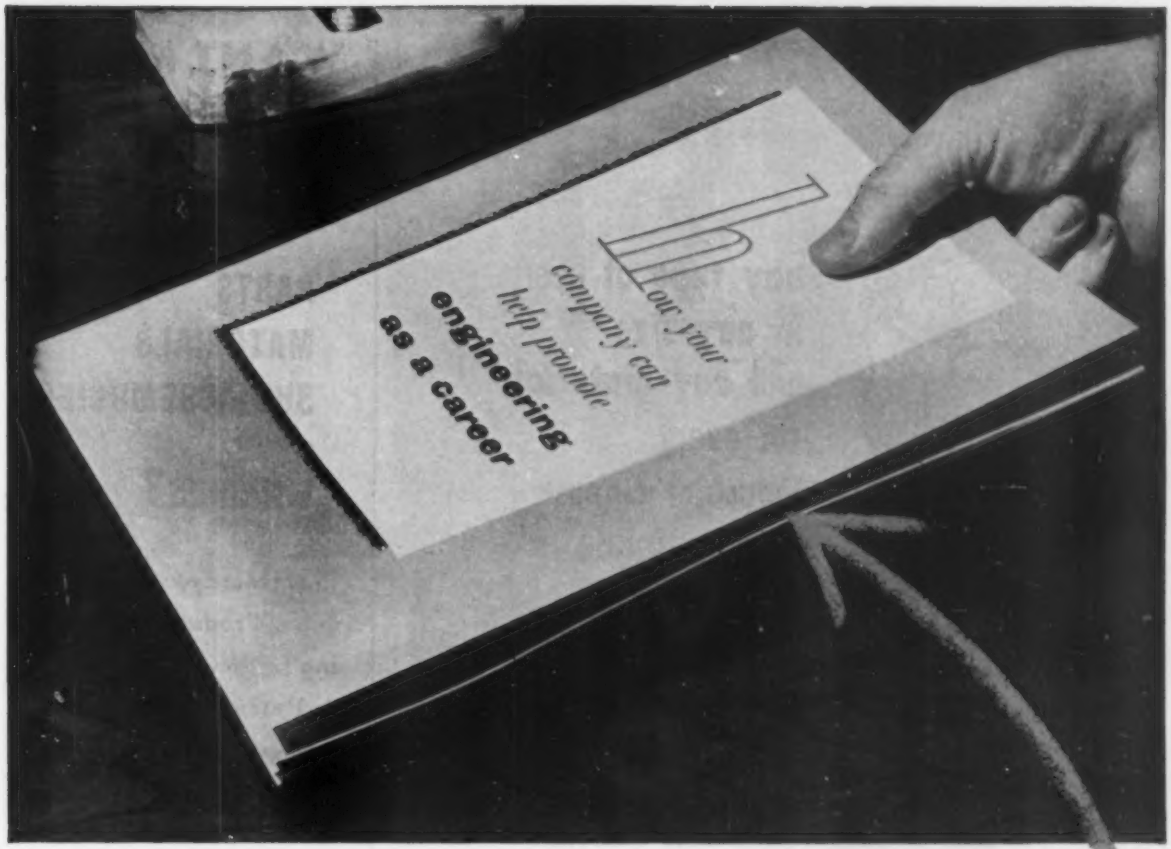

HERE'S HELP

for your engineer-recruitment problem

Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

The booklet reproduced here was prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you make your advertising work most effectively in recruiting engineers for the future.

1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
4. It offers specific suggestions as to what you can do (from present manpower).
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Many advertisers are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs.

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THE ADVERTISING COUNCIL
for the
ENGINEERS' JOINT COUNCIL

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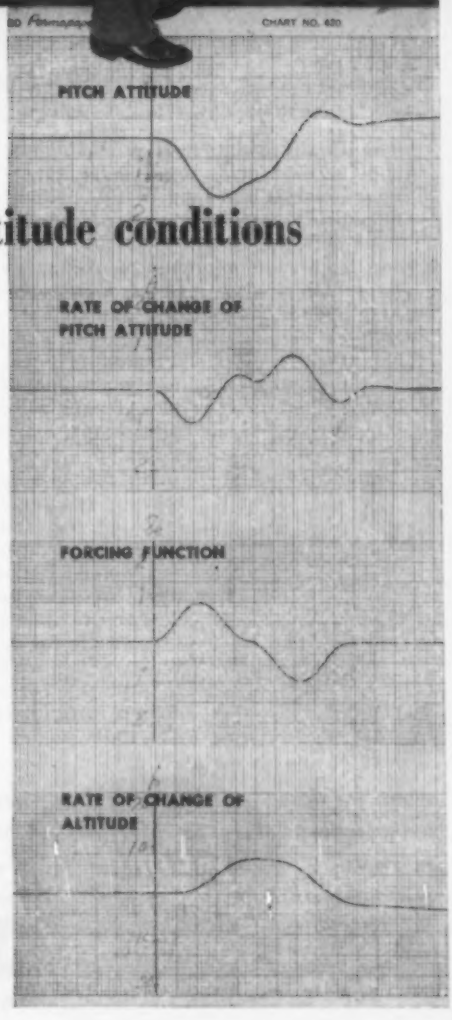
Four-channel recording correlates simulated jet bomber airspeed and altitude conditions



At Eclipse-Pioneer, engineers make good use of Sanborn 4-channel recording systems in conjunction with high precision analogue computers to establish performance criteria for automatic flight systems and components.

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Available for light, normal or heavy duty on shafts from ½" to 3 15/16". For more information write for catalog No. 109, today.

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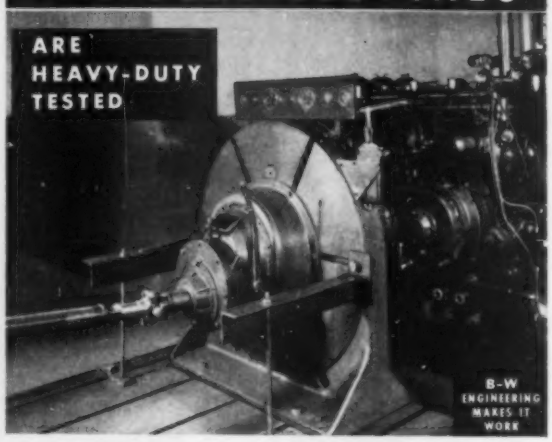

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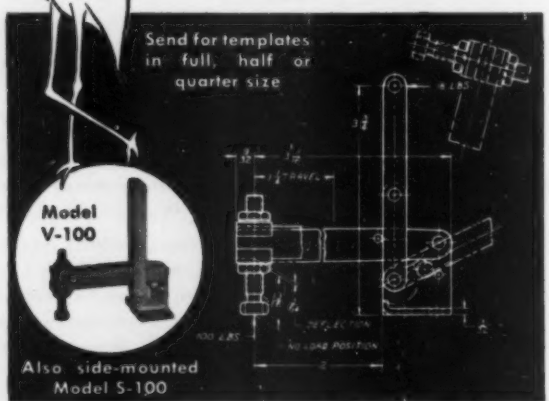

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★ ★ ★

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Give Blood Now

CALL YOUR RED CROSS TODAY!

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Business Executives!

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- ☐ Have you informed employees of your company's plan of cooperation?
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- ☐ Have you conducted a Donor Pledge Campaign in your company?
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SEALING COMPOUNDS

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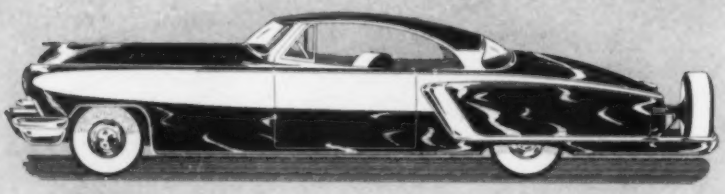
of Automobile Bodies



...by sealing out problems of DUST • WATER • RUST • AIR

Sleek new automobiles, efficient trailer homes, rugged heavy-duty trucks . . . all contain fine qualities that must be protected and sealed against destructive attacks of the elements. Sealing quality *in* begins with sealing dust, water, rust and air *out!*

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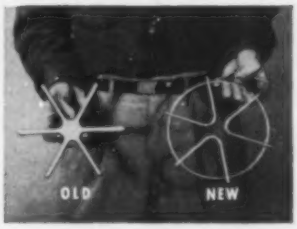

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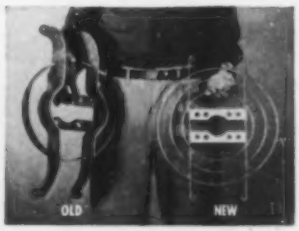

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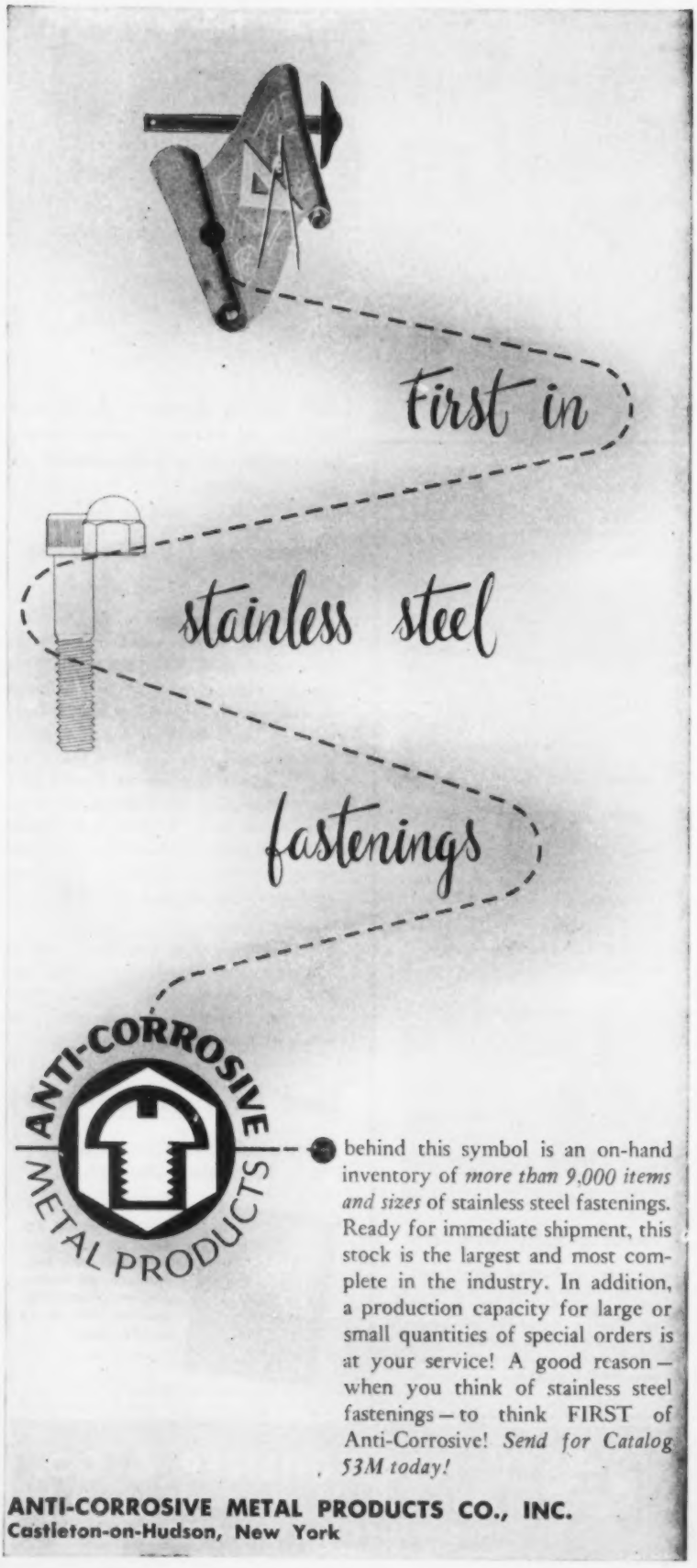
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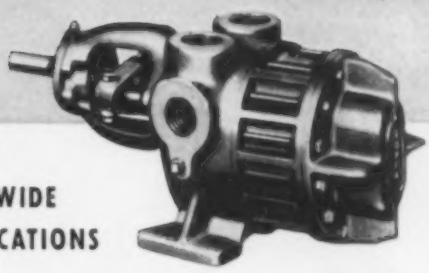

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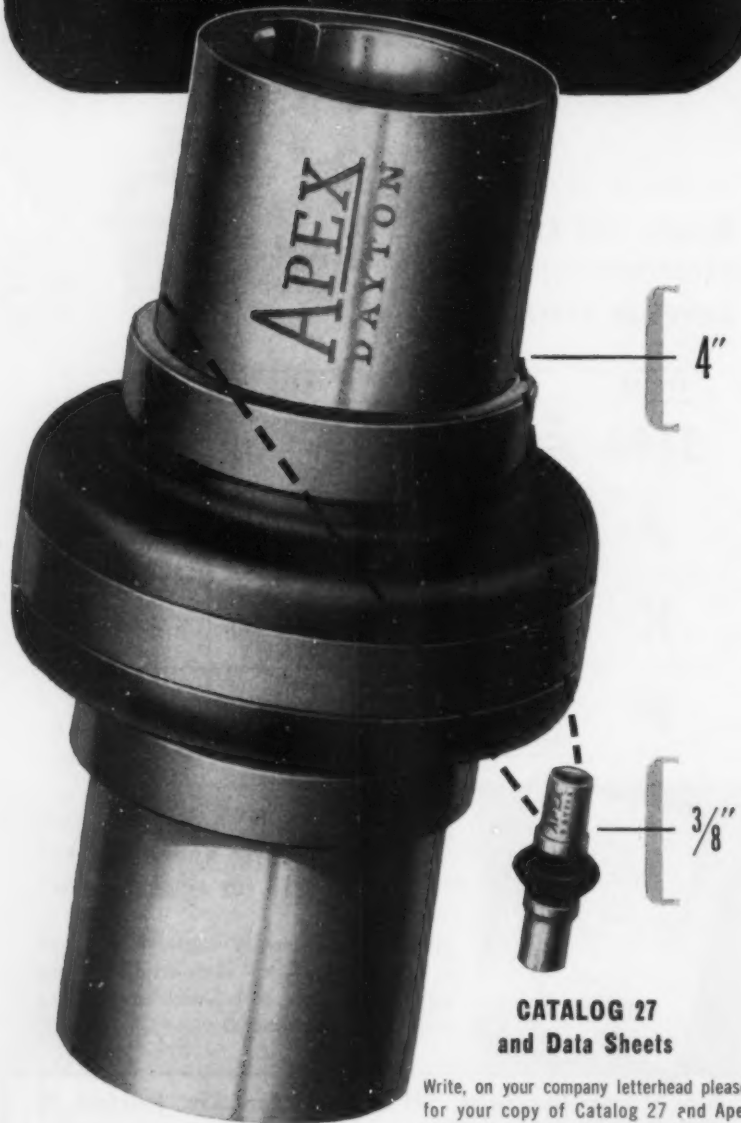

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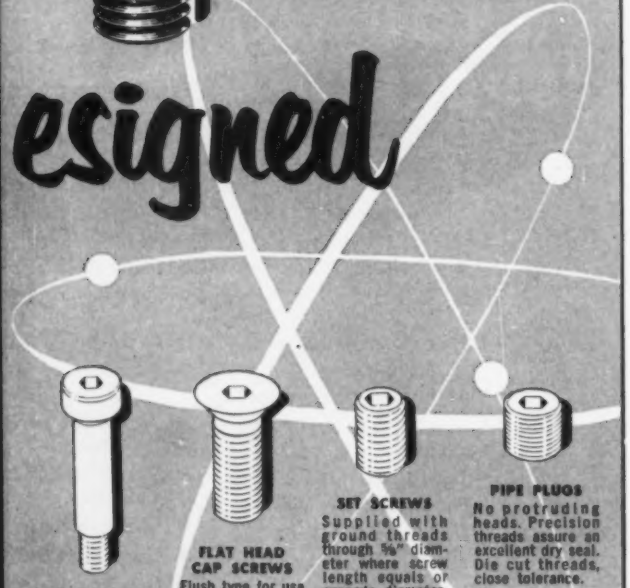

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2 to 5 triple pole, shorting or non-shorting

Spacing: 15° or 20°, shorting or non-shorting

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No. of decks: According to requirements

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Max. operating voltage: 120 V., a.c.

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Detent: Ball and spring

Weight: Approx. 1 oz. per deck

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Manufacturers of Precision Electrical Resistance Instruments

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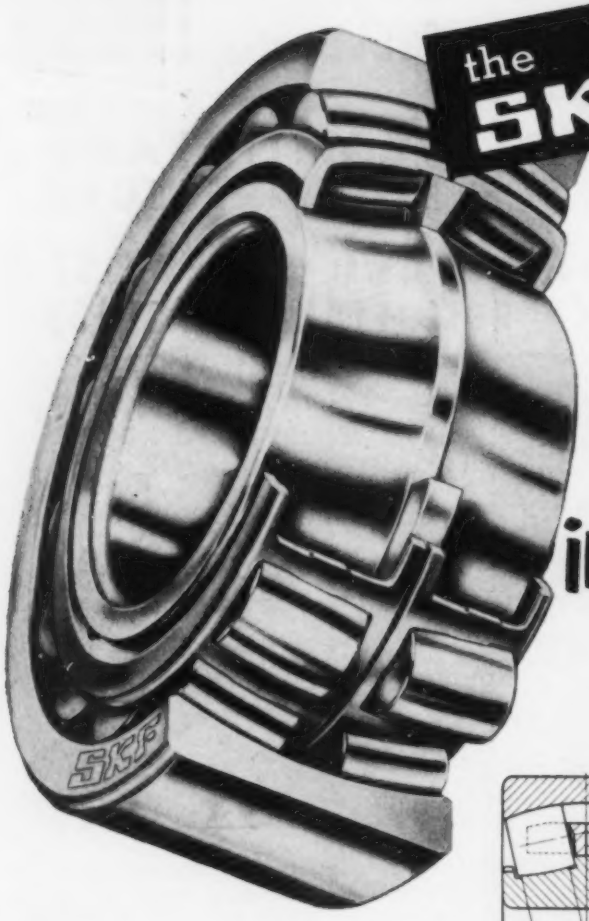

the SKF

improvement of internal design of spherical roller bearings

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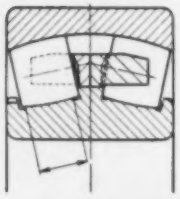

This is the Spherical Roller Bearing design originated by SKF *more than 30 years ago.* The cross-section shows how the integral inner ring flanges, and the undercuts adjacent thereto, limit the effective length of the rollers.

Now, SKF, originator of the Spherical Roller Bearing, has again provided industry with another anti-friction *first.*

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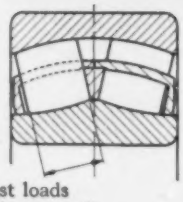

Here is the latest SKF improvement, a *revolutionary advance in design.* Effective roller guiding is accomplished by means of a separate ring. The need for undercuts is eliminated! This type of guide ring permits the rollers to take the position which their contact with the rings dictates. This assures uniform load distribution over the entire length of the longer rollers at all times. *Result* — greatly increased capacity and life.

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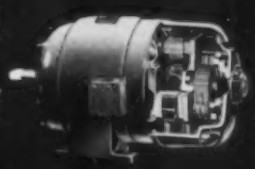
give your brains a chance



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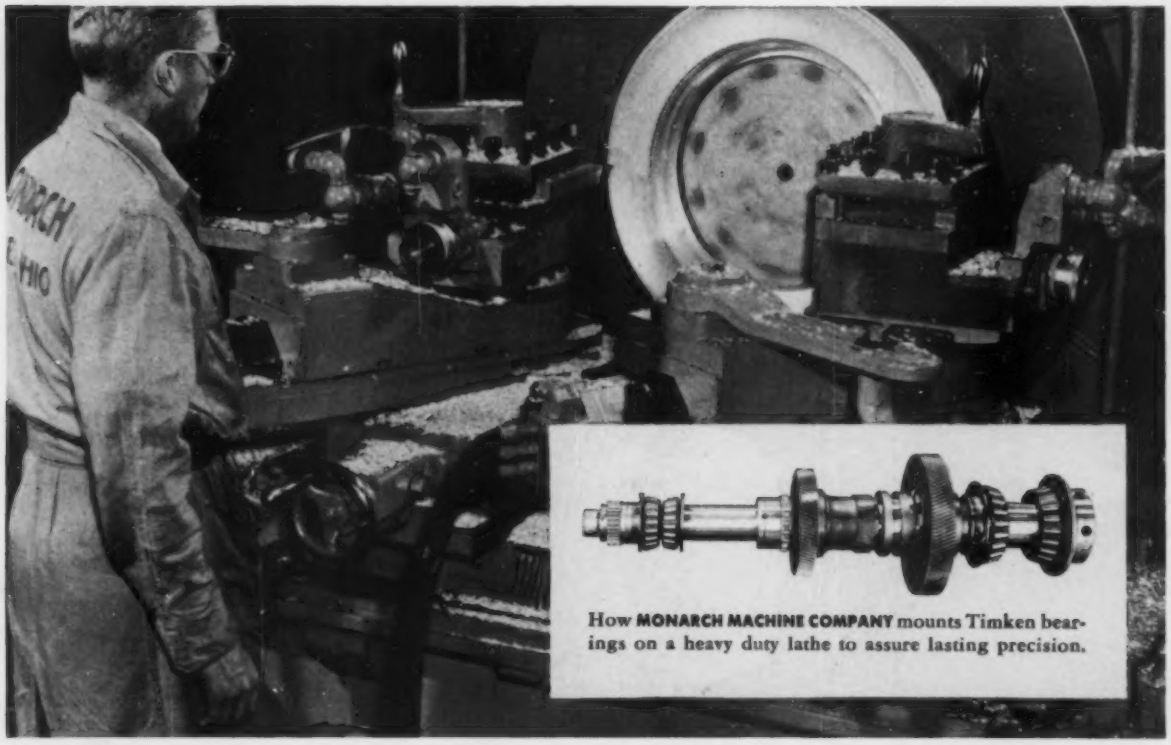

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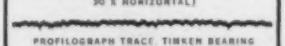

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OPTICAL FLAT. PERFECT FINISH

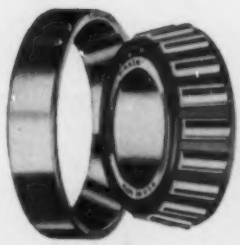
SMOOTH TO MILLIONTHS OF AN INCH

Surface finish of high quality Timken bearing rollers and races is so smooth that it takes a profilograph to measure its smoothness. This instrument measures surface variations to a millionth of an inch, as shown at the left.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST →▯← LOADS OR ANY COMBINATION →✳←